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THE JOURNAL OF WILDLIFE MANAGEMENT

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WILDLIFE ADMINISTRATION AND HARVEST IN POLAND[1]

Richard D. Taber

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Until World War II Poland was a country of large estates. With the establishment of a socialist form of government in 1945, these estates were confiscated, the arable portion parceled out to the resident farmers, and the forest portion kept under state control. Of the present total area of about 31 million hectares (77 million a.) about 65 percent is devoted to agriculture. Most farms are quite small—90 percent are 10 hectares (25 a.) or less—and are farmed with horses. About 7 million hectares (17.5 million a.) are forest lands. About 2.5 million hectares (6 million a.) consist of bog and marsh (Haber, 1959; Steinberg, 1960).

It was my privilege to visit Poland in the summer of 1960, as a United States Specialist in Forest-Wildlife Relations, under the U.S. Department of State. While there I had an opportunity to confer with officials of the government and the Polish Hunting Society concerning the postwar system of wildlife administration, a description of which forms the body of this report. I wish especially to acknowledge the help of Director Kreutzinger, of the Institute of Forest Research, Warsaw, and R. M. Dzieciolowski of his Wildlife Research staff.

[1] Contribution from the Montana Forest and Conservation Experiment Station and the Montana Cooperative Wildlife Research Unit (Montana State University, Montana State Department of Fish and Game, U.S. Fish and Wildlife Service, and The Wildlife Management Institute cooperating). Support for travel was furnished in part by the U.S. Department of State, the Office of Naval Research, and The Wildlife Management Institute.

OWNERSHIP OF WILDLIFE

In Poland all free living wild animals are owned equally by all citizens of the nation, and in their name are administered by the government. The landowner has no legal rights concerning wild animals except protection from or recompense for game damage. There is some recognition, however, of the fact that the community should be rewarded for growing a crop of game. The hunting lease, and payment for game killed, both explained below, provide a source of income to the local community, although not directly to the individual landowner.

WILDLIFE ADMINISTRATION

All regulations regarding wildlife have been made and administered under the Ministry of Forestry since 1945 to insure a proper balance between game and forests so that forest damage is minimized. The whole country, with the exception of national parks and nature reserves, is divided into hunting reviers which amount to wildlife management units. These vary in size from 3 to 10,000 hectares (7,500–25,000 a.) and typically include a great many farms under different individual ownerships. Altogether there are 4,500 hunting reviers in Poland. They total 29 million hectares or over 90 percent of the total area of the country (Haber, 1959). Virtually all of them are under lease to groups of hunters called hunting circles. Each hunting circle may control more than one revier; often a

circle will lease one farm-game and one forest-game revier.

Each revier on which at least 60 percent of the land is forested is directly under the field administration of the Ministry of Forestry, which makes all management plans. Where less than 60 percent of the land is forested, the direct administration of the revier is under the hunting circle that holds the lease. About 80 percent of all reviers are under hunting-circle administration. The remainder are under Forestry administration.

Not every revier is leased by a hunting circle. Currently (1960) there are about 477 areas not taken.

The Hunter

Webb's (1960) remark that to be a hunter in West Germany is a mark of distinction could be applied equally to Poland. There are strong similarities throughout central Europe in the language, dress, customs, and values of hunting, and the common basis for similarities is the aristocratic hunting tradition of feudal times. This situation prevails despite the fact that the hereditary aristocrat, the scion of an estate-owning family, who was the typical hunter through the centuries until the Second World War, is no longer prominent in the socialist countries. He is usually dead or exiled, and his estates are confiscated. However, his hunting tradition has been picked up by a new generation, consisting on the whole of the better educated and more prosperous citizens—educated because they must be educated to obtain a hunting license, and prosperous because the expenses connected with hunting are substantial. However, it is also said that there are many farmers and workers with only a primary school education who, because of their extensive experience with wildlife, have successfully passed the examination for the hunting license.

In Poland, a person who desires to be a hunter applies to the Hunting Society for membership in a class of instruction. Such a class lasts about 35 hr., and is given in 2- or 3-hr. sessions 4 evenings a week for 1 month. The class of 30 or more students is taught by an expert hunter or wildlife biologist. Subjects covered are the biology of wildlife species, and ways of hunting and conserving each; arms and ammunition and their proper care and use, including safe gun handling and firing on the range; laws and regulations.

Following the course there is a rather stiff examination, which is successfully passed by about two-thirds of the aspirants. If this examination is passed, a certificate is issued by the Hunting Society. This certificate must be shown when a permit to buy a shotgun is obtained. The permit (which costs 112 zloties the first year, and 100 zl. annually thereafter) is issued by the militia, but only after it has been determined that the applicant is not a criminal. (A zloty is worth between 2 and 4 United States cents.)

The would-be hunter then must join the Hunting Society which charges him a 300-zl. initiation fee. Then he is free to apply to the hunting circle of his choice, which is usually the one formed by the people where he works.

If he desires to shoot deer, the trophy game of Polish hunting, he must pass a further course of instruction covering deer hunting in detail, especially the techniques of selecting the animals to be shot. Only after having passed this course may the hunter obtain a permit to purchase and own a rifle. Lending and borrowing of rifles is not allowed.

If his hunting circle does not control sufficient deer hunting to satisfy a hunter, he may apply for a permit to shoot on some portion of the state forests which is not leased by any circle. Such a permit for red deer would cost 30 zl. and would specify where and when to hunt and exactly what class of animal to shoot.

The hunter might lose his hunting privilege if jailed for some crime. In addition, his own hunting circle might expel him for flagrant disregard of regulations. His hunting privilege may be temporarily lost, as will be explained, by the excessive accumulation of red points at the trophy show.

These difficulties, restrictions, and ex-

penses are in marked contrast to those prevailing in the United States. Consequently, in Poland there are only 37,000 licensed hunters, of whom 7,000 are also licensed to hunt deer. Even with the high population density, hunters in Poland are so few that each individual hunter enjoys over 13 times the hunting area that is available to the average hunter in the United States. The two countries are contrasted, in this respect, in Table 1.

TABLE 1.—HUMAN POPULATION DENSITY, PERCENT OF LICENSED HUNTERS, AND AREA PER HUNTER COMPARED FOR POLAND AND U.S.A.

Country	Population Density (per sq. mi.)	Licensed Hunters (percent of population)	Hunting Area per Licensed Hunter[1] (acres)
Poland	243	0.12	1950
U.S.A.[2]	59	7.30[3]	148

[1] Ninety percent of total area in Poland is open to hunting; the same proportion is assumed for the United States.
[2] Exclusive of Alaska and Hawaii.
[3] Anonymous (1956).

The Hunting Circle

The hunting circle begins with at least 10 members. If it increases to as many as 50, it is divided into two circles. There are (1960) about 1,200 hunting circles in Poland. Each circle has its own organization, including the offices of President, Secretary, and Hunt-master.

The hunting circle is responsible for all wildlife management, conservation, and administration on the one or more reviers which it leases. It either makes up the management plan itself (on predominantly agricultural land) or carries out the management plan produced by the Ministry of Forestry (on predominantly forest land). It leases the hunting rights on the revier. This is the equivalent of a payment for trespass privileges. Each lease covers a period of 10 years, whether for farm or forest revier. The lease money is spent on some community project in the area where the revier is located—perhaps a bridge or road improvement. The value of the lease is set by the state, according to the quality of the revier; it usually runs between 0.2 and 0.5 zl. per hectare. Often the hunting circle employs a gamekeeper to feed the game in winter, control predators, assist in drives, and generally look after the area. This man often has other employment as a farmer, forest ranger, or forest worker. The circle pays him about 1,000 zl. per month.

New members of the hunting circle join by applying and being accepted. A person not accepted in one circle may try to join another. Individual hunting circles may have their own rules and traditions, such as requiring that a new member accompany the hunt for one year unarmed. Often the circle levies fines for faults in shooting, such as shooting toward the beaters after the horn-blast which signals that only shooting away from the beaters is allowed. Individual members may on occasion invite hunters from other circles to be their guests.

From time to time the state may make certain stipulations regarding the hunting circle. At present writing, for example, 30 percent of the membership of a circle must be from village and country to insure hunting opportunity for rural citizens.

When the circle stages a hunt, the members travel from their homes to the revier, which may be a considerable distance away. They often room and board with the local residents. For hare and boar hunting, particularly, beaters are employed. These are local residents and are paid, according to experience, 20 to 30 zl. per day. One or two beaters per gun is the usual proportion. The various expenses of a hunt, including transportation of hunters, payment per head of game killed (to the local district), and "income" from game sold to the state (as explained below) are controlled by the circle Hunt-master, who assesses or pays each hunter at the end of the hunt. In addition to these various transactions, each hunter makes a monthly contribution of 10–100 zl. toward the expenses of his circle. Thus the finances of hunting are rather complex, and the need of a Hunt-master to handle the bookkeeping is obvious. The Hunt-master has still another related responsibility—preparing the shooting plan and insuring that

it will be adhered to. The shooting plan is explained below.

The Hunting Society

The Hunting Society, to which every licensed hunter must belong, and to which each contributes 200 zl. annually, constitutes the link between the government and the hunter. The society undertakes the education and testing of the aspiring hunter. It maintains contact with him through its bimonthly magazine (*Lowiec Polski*), for which he pays 60 zl. annually. The Society organizes annual district trophy shows, to which each hunter must submit the antlers and lower jaw of each of the male deer (red, roe, or fallow) he has shot that year. Along with each such trophy, he must submit the permit or instructions under which he was authorized to shoot it, issued either by the Hunt-master of his circle or by the forester. Antlered game is shot under a system which aims at the improvement of the stock, especially with regard to antler development. The planned kill for any given area is divided into "trophy" and "elimination" animals, with the latter making up the majority. Whether a male animal falls in one category or the other depends mainly on the development of his antlers in comparison with the "normal" for the species and age. Thus the hunter must be able to estimate age, and then compare the antlers he sees with a theoretical "normal," pictures of which are given in books of hunter-instruction. If the antlers are definitely subnormal, the animal may be shot under an "elimination" permit; if definitely normal or better, it may be shot under a "trophy" permit. In the "trophy" class, only stags over 6 years old are supposed to be killed.

When the big game hunter sets forth, he is given specific instructions regarding the species, sex, age, and quality of the animal he is to take. These instructions, then, are posted at the annual trophy show along with the antlers and jaw of the animal he actually did shoot. The judges (skilled hunters and foresters with wildlife training) award points for his success, or lack of it, in following the instructions of his permit. For perfect success he is awarded six green points, for fair success three, etc. For poor success he is given one or more red points, with six red points being awarded for some spectacular blunder, such as shooting a trophy stag on an elimination stag permit. Six red points lead to suspension of hunting privileges for one year, but are seldom awarded. Rather, this system displays the hunter's skill to his companions, and so exerts a social pressure for improvement.

In addition to its continual efforts to raise the high competence of Polish hunters still higher, the Hunting Society conducts an extensive scheme for popularizing wildlife conservation in the primary schools. It also maintains a central museum in Warsaw and supports a certain amount of wildlife research. Probably its most important routine function, however, is its approval, or adjustment, of the shooting plan which must be submitted annually for each revier.

The Shooting Plan

In each revier which is less than 60 percent forested, the hunting circle members must prepare a shooting plan. This plan presents an estimate of the the late winter population (the breeding stock) for each game species, along with the estimated increase and proposed harvest. In addition, the plan provides information on proposed management measures, such as winter feeding, predator control, cover improvement, and the planting of food patches. The results of the shooting plan of the previous year are also presented. The shooting plan is made with the help of the more experienced members of the circle, often including the District Forester, who has had some wildlife science as part of his forestry education. The plan is submitted in turn to the District Council, the Provincial Council, and the Central Headquarters of the Hunting Society, where it is reviewed jointly with technically trained representatives of the Ministries of Forestry and Agriculture. Any necessary corrections are made; it is then approved and returned. The shooting plan guides the activities of one hunting circle on a particular revier for the coming year.

TABLE 2.—ANNUAL KILL OF PRINCIPAL POLISH GAME SPECIES (1958–59), IN RELATION TO HABITAT[1] AND NUMBER OF HUNTERS

Habitat	Species	Total Kill	Kill per Licensed[2] Hunter	Kill per Square Mile of Habitat	Acres per Head Killed
Forest	Red deer	6,593	0.9	0.3	2,745
	Roe deer	11,693	1.7	0.5	1,550
	Wild boar	21,228	0.6	0.7	885
Farm	Hare	536,084	14.5	6.8	94
	Partridge	325,850	8.8	4.2	154
	Pheasant	7,714	0.2	0.1	6,400

[1] From data in Steinberg (1960); forest habitat is considered to consist entirely of forested land, farm habitat to consist entirely of arable, meadow, and pasture land.
[2] The general hunting license holders may hunt boar and upland game; for deer a special license is required. See text.

If the revier is made up of over 60 percent forest, the shooting plan is prepared by the District Forester, and is approved by the office of the Minister of Forestry. According to a recent regulation, the District Forestry staff is given the task of fulfilling the shooting plan on forest reviers, as far as the kill of big game is concerned, if the hunting circle is unwilling or unable to do so. The 10 days from February 10 to 20 are designated for this mopping-up operation, which is deemed necessary for the well-being of the forest.

Ordinarily, deer are harvested at about the rate of 25 percent of the spring population annually. Wild boar, under sustained-yield management, are harvested at the rate of 50 percent of the fall population. At present, it is considered necessary to reduce boar populations, and thus the rate of harvest has been increased.

The shooting plan is the principal instrument through which government wildlife policy can be carried out. It gives complete control over measures both for production and harvest of the wildlife crop. It also gives an excellent source of statistics on the kill. Table 2 shows total kill and kill per unit of range for the principal Polish game species.

It is apparent (Table 2) that the kill per unit area is relatively low. Under the Polish system of game harvest, a rather heavy kill of the available game is taken; consequently the low yield per unit area reflects low game densities. This is a matter of deliberate policy in the forest. Previously in Poland, and currently in Germany and Czechoslovakia, there has been heavy damage to forest trees, both by bark-eating and browsing on reproduction by deer populations maintained at extremely high levels of population density. In agricultural areas, on the other hand, the Polish government and the Hunting Society would like to raise the game density.

The wild boar, unlike the other principal game species, is numerous. Regulations for hunting boars have been systematically relaxed, especially with regard to woods of under 1,000 hectares (2,471 a.). Boars in such woods cause extensive damage in the surrounding agricultural land, and therefore must be rigorously controlled.

The shooting plan, which fixes the kill of each game species, is the only limitation on the kill. The daily bag limit, so much a part of North American wildlife administration, is not used. Instead, the Hunt-master assigns each member of the circle his season bag. Later on, the situation is reappraised, and unsuccessful hunters relinquish part of their allowable quota to successful ones. In this way, when the season has drawn to a close, the circle has fulfilled the kill allowed by the shooting plan.

Hunting Regulations

The open hunting seasons tend to be longer than the seasons which prevail in the United States. This is readily understood when we recall that in the United States (and to a lesser extent Canada) the length of the season is modified to control the total kill and also, often, to suit the land-

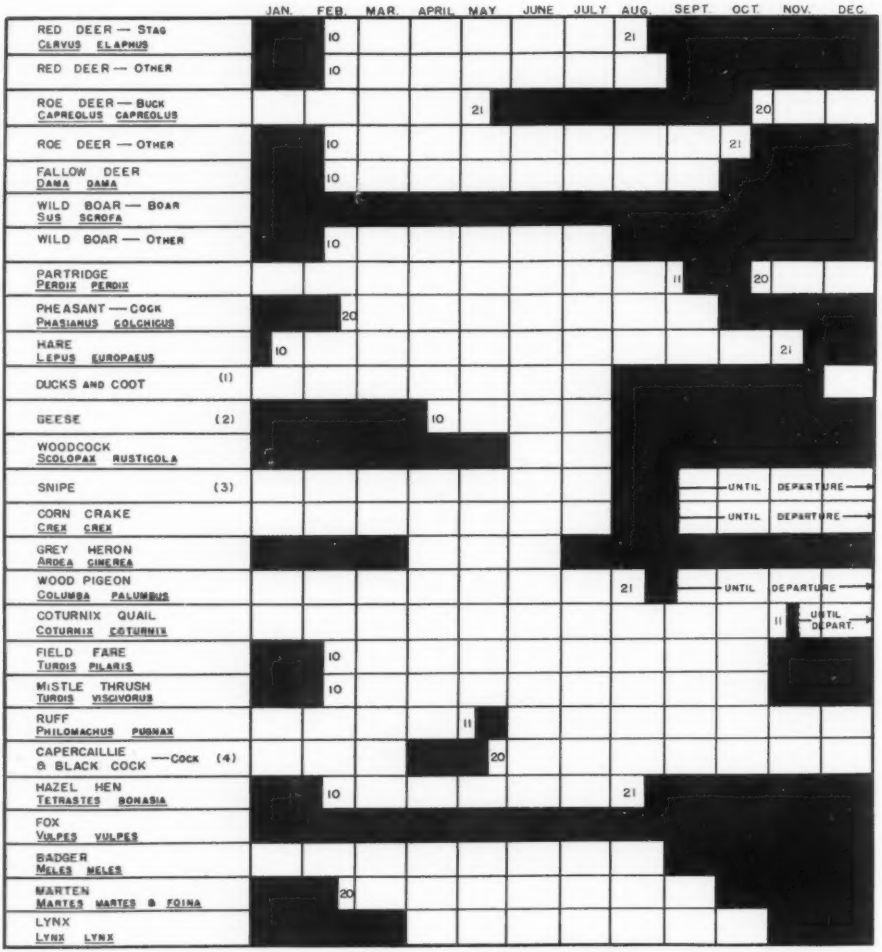

FIG. 1. Hunting seasons (1960) for the principal game species of Poland. Dark areas represent open seasons. (1) *Anas platyrhynchos, A. strepera, A. penelope, A. acuta, A. querquedula, A. crecca, Fulica atra;* (2) *Anser anser, A. arvensis* (*fabalis*), *A. albifrons, A. erythropus;* (3) *Capella media, C. gallinago, Lymnocryptes minimus;* (4) *Tetrao urogallus* and *Lyrurus tetrix.*

owner. Neither of these conditions is a problem in Poland.

The closed and open seasons (for 1960) are as follows, with scientific names given either in this section or in Fig. 1.

1. *No open season.*—European moose (*Alces alces*), Sika deer (*Cervus nippon*), mouflon (*Ovis musimon*), otter (*Lutra lutra*), raccoon-dog (*Nyctereutes procyonides*), squirrel (*Sciurus vulgaris*), bustard (*Otis tarda*), female of *Urogallus, Lyrurus,* and *Phasianus,* and all birds and mammals

not otherwise listed. The protected list totals 128 species, genera, and families (Haber, 1959).

2. *No closed season.*—Muskrat (*Ondatra zibethicus*), polecat (*Mustela putorius*), wolf (*Canis lupus*), feral domestic dog and cat, two accipitrine hawks (*Accipiter gentilis* and *A. nisus*), two harriers (*Circus aeruginosus* and *C. cyaneus*), two crows (*Corvus cornix* and *C. frugilegus*), a jay (*Colaeus monedula*), and a magpie (*Pica pica*).

3. *Partial open season.*—These animals are listed in Fig. 1, along with their open seasons. It may be seen that the spectrum of game species, characteristic of central Europe, is broader than that of North America; it includes a heron and two thrushes. Also, certain seasons differ from those to which North Americans are accustomed. Several birds, such as blackcock, capercaillie, and ruff, are hunted only in the spring, when the males are displaying. Woodcock (males only) are hunted in the spring and also in the fall. The season for waterfowl (especially geese) and woodcock is particularly long. There are no treaty agreements in Europe comparable to the Migratory Bird Treaties between the United States, Canada, and Mexico. Consequently the various European countries, while acknowledging the need for waterfowl conservation, tend to have somewhat more liberal laws for migratory than for resident game. There are, however, some special measures in Poland for the conservation of waterfowl. Lakes commonly used during migration are closed to hunting, as is also the Baltic shore, from 3 km. (almost 2 miles) offshore to 8 km. (almost 5 miles) inland.

In addition to protective legislation, there are certain regulations which modify hunting methods. For example, a minimum of six guns is required on a hare hunt. Only half of the revier may be hunted for hare in any given year. The use of circular drives for hare is forbidden; the usual drive at present is one in which a line of beaters approaches a line of hunters, of which the ends are forward. Such regulations, which may change from year to year, are published and explained in the hunters' magazine, which provides an excellent channel of communication from the government to the hunter.

The State Demand for Game

The state obtains from each hunting circle a portion of the game shot. In 1960 the regulations required that the following proportions of the kill be sold to the state, and established the following rates of payment to the hunters:

hare: 60 percent; 70 zl. for those of first class (over 4.5 kg. (10 lb.) and not badly shot) and 45 zl. for those of second class
partridge: 60 percent; 17 zl. for first and 10 zl. for second class
pheasant: 60 percent; 75 zl.
mallard: sale optional; 13 zl.
garganey (a teal): sale optional; 10 zl.

Big game must all be sold to the state if over a certain size or weight. Wild boar under 40 kg. and cervids which are either female or under 1 year need not be sold, although they may be if desired. Prices paid by the state are these: red deer and boar—15 zl. per kg.; roe and fallow deer—19 zl. per kg. All of these are dressed weights, with the head removed in the case of antlered game. The hunter keeps the antlers, which are highly valued as trophies.

Most big game is killed on the forest reviers, and here the forest district is responsible for dealing with the state purchasing agency (*Las*). When the hunter has killed a big game animal on such a revier, he cleans it, removes the head (if antlered), and notifies the forest guard, whose duty it is to turn the carcass over to the state. The carcass is considered as the property of the forest district; consequently the state payment goes to the treasury of the forest district. If the forest revier is unleased, the hunter is paid a premium amounting

to about half of the value of the game, as follows:

red deer: stag—500 zl.; hind—300 zl.; calf—150 zl.
fallow deer: buck—270 zl.; doe—200 zl.; fawn—100 zl.
roe deer: buck—100 zl.; doe—75 zl.; fawn—40 zl.

Should the hunter desire to keep a female or young animal for his own use, he must pay the forest district the difference between the premium and the state price, so that the forest district receives the same amount whether the animal is kept by the hunter or turned over to the state.

Only the state can sell game, but some of it is exported. Most of the game obtained in this way by the state is sold within Poland. Exports in 1958 were as shown in Table 3; they amount to roughly one-tenth of the game killed.

Just as payment goes to each forest district for big game killed, so payment is made to the local government administration for small game killed. The individual hunter makes this payment, which amounts to about 15 percent of the market value of the game. Fees for the principal small game species are: hare—8 zl.; fox—30 zl.; capercaillie cock—15 zl.; blackcock—5 zl.; pheasant—15 zl.; mallard—5 zl.; other small game birds—2 zl.

Game Damage

The principal damage by game is done by boars in oats and potatoes, and in young oak and beech plantations. Red and fallow deer damage all grain, and also young stands of conifers. The special regulations aimed at reducing the number of wild boars near agricultural land have been mentioned. The universal custom of winter feeding is also intended to keep the big game animals from barking conifers, a serious problem.

Damage from upland game birds is negligible, but if pheasant populations increase there might be damage to newly seeded areas. At present, farmers appear to like high populations of partridges and pheasants, since they consider these birds their allies in the war against insect pests.

TABLE 3.—EXPORTS OF WILD GAME FROM POLAND (1958), WITH VALUES AND DESTINATIONS[1]

Type of Meat	Destination	Amount (metric tons)	Value (zloties)
Venison	West Germany	145.6	25,500,000
	Sweden	6.4	1,300,000
	Switzerland	3.1	600,000
	Total	155.1	27,400,000
Hare	West Germany	228.0	37,100,000
	Switzerland	28.3	5,400,000
	France	12.0	2,700,000
	Greece	5.0	1,000,000
	Total	273.3	46,200,000
Grand Total		428.4	73,600,000

[1] Information from Agricultural Attache, U.S. Embassy, Warsaw.

Hares are the most numerous of the upland game species, and are particularly troublesome when they eat the bark of fruit trees in winter. Trees are protected by wrappings of straw, and attempts to develop effective repellents for hares and also for big game animals are under way.

Wire or wood fencing is used to protect forest plantations but is apparently not used around the many tiny farm fields. The shooting plan, and its execution, are the means by which the state can insure that game populations are controlled by optimum hunting pressure. Until 1939, state insurance against game damage could be taken out by the farmer, but this arrangement is no longer in effect. Now the damage is assessed by the District Forester or his representative. If this estimate is not accepted, a Damage Appraisal Board is called in. This board consists of the District Forester, a representative of the municipality, and a representative of the local Forestry and Agriculture Office of the Ministry of National Affairs. If the decision of this board is not accepted, the matter may be taken to court.

When a fair value of damage done has been determined and agreed to, payment is made from the state treasury. The hunting circle, in other words, is not held liable for

game damage on a revier which it has leased. During a recent year payments for game damage in Poland amounted to 80 million zl., or a little more than the value of the game meat exported.

CURRENT DEVELOPMENTS IN WILDLIFE CONSERVATION

The principal concerns for the future are to minimize field and forest damage by big game, and to increase the production of upland game. Before the Second World War there was in Poland an annual kill of 3 million pheasants, 3 million partridges, and 5 million hares. Recent kills have averaged about 7,000 pheasants, 300,000 partridges, and 500,000 hares. Because of boundary changes following the war, the country includes a different area from the prewar period, but the total acreage is similar. Farm game production on the estates of the prewar era was therefore about 10 times as high as at present. Presumably this situation existed largely because on these estates wildlife production was a primary aim, with a correspondingly intensive level of wildlife management. The state has instituted a number of breeding centers, modeled on those of Czechoslovakia, to stimulate small game production. There are now 25 such centers on state farmland, and the next 5-year plan calls for 50, as well as 30 each on state forest land and land controlled by the Hunting Society.

Each of these breeding centers is about 10,000 hectares (25,000 a.) in extent, and is managed intensively for game, along with primary field or forest crops. All predators are closely controlled, eggs exposed by mowing are gathered and incubated, and cover management for maximum production is practiced along with supplementary feeding. The game produced on these areas is transplanted, and is also thought to spread naturally. It is anticipated that when the rapid increase of Polish small game has been accomplished, breeding centers will be closed down.

Education

The Polish Hunting Society conducts a scheme, already mentioned, for popularizing wildlife conservation in the primary schools. Their magazine regularly deals with conservation topics, such as the recognition of protected Raptores. In the secondary schools of agriculture, wildlife conservation will shortly be part of the regular curriculum. In secondary professional technical schools (for forestry students) introductory courses in wildlife biology and management total 160 hr. In the Colleges of Agriculture at Warsaw and Poznań, where the forestry course requires 5 years, forestry students may specialize in wildlife conservation and receive from 170 to 212 hr. in this field. In addition, steps are being taken to introduce courses in wildlife conservation into the curricula in agriculture and zoology in all other colleges of agriculture of academic standing (Haber, 1959).

Research

The Institute of Forestry, at Warsaw, is the only organization with a Wildlife Department specifically charged with the solutions of pressing problems in wildlife conservation. In addition, however, wildlife research is carried on under the Polish Academy of Sciences (Experimental Animal Breeding, Mammalogy, Ecology, and Parasitology Departments); Central College of Agriculture at Warsaw (Department of Forest Zoology, Game Management and Hunting, and Department of Meat Science of the Veterinary Faculty); Polytechnic College at Gdańsk (Chair of Technology of Animal Products); College of Agriculture at Kraków (Department of Animal Anatomy and Histology); College of Agriculture at Poznań (two Game Laboratories); Polish Hunting Society (Group for Scientific Game Research and Scientific Research Station) (Haber, 1959).

DISCUSSION

The administration of hunting in Poland appears to be a logical development, under the socialist form of government, from the previous pattern of private estates. Hunting

is highly organized both for self-regulation and for the production of an annual yield of game for sale. The cost of administration, conducted largely through the Hunting Society, is small except for the game damage payments from the state treasury. These payments should decline as management improves.

It is of interest to compare the situation in Poland, with its socialist form of government, with that in democratic, capitalistic West Germany. From the report of Webb (1960) we learn that West Germany, like Poland, is divided into hunting reviers. Rather than being established by the government, however, they are created from private holdings by mutual agreement among neighboring owners, with the only control being a minimum limit on size—185 a. in single ownership and 370 if more than one landowner is involved. These minimum acreages are far smaller than the minimum revier size in Poland—about 7,500 a. The West German revier is leased directly to a single private individual, who pays a substantial sum for it. This man will invite a number of friends to hunt with him. In Poland, on the other hand, the lease is set by the state, and all members of the circle share hunting equally. In Poland, about 780 hectares (1,950 a.) are available for every hunter. In West Germany, this figure is only 157 hectares (390 a.) (Koehler, 1960; Steinberg, 1960), but climate, soil, and intensive management insure a higher productivity.

In both countries, the proportion of the population that hunts is minute by North American standards—0.12 percent in Poland and 0.26 percent in West Germany (Koehler, 1960).

The reason that the number of hunters in these two countries is so small is, of course, that every man by no means has the power to obtain a hunting license and maintain the expenses connected with hunting. In each country, the aspiring hunter must study industriously and pass examinations in all matters pertaining to hunting, game biology, and the use of firearms. In each country, the hunting fraternity is an elite social group and is largely self-governing. The result of these various factors is that even under these two different systems of government, the basic pattern of hunting is the same—it is a direct development from the hunting estates and the aristocratic hunting traditions of the 19th century.

With regard to the ownership and financial return from wild game, the two countries are in strong contrast. In Poland these functions are a state concern, with the state claiming and selling a large proportion of the bag; in West Germany these functions are carried out by the owner of hunting rights. The basis for this difference is in the legal ownership of game—although in Poland this is vested in the state for the people, in West Germany resident game belongs to the owner of the land, and, by sale of rights, to the holder of the hunting lease.

On the whole, it would appear that the two countries are basically similar in hunting legislation, customs, and traditions, and that the differences between them stem from differences in the legal ownership of game.

SUMMARY

Poland covers 77 million a., of which about 65 percent is in farms (mostly 25 a. or less), 23 percent is forest, and 8 percent is marsh. Wildlife is owned by the citizens of the state, but some income from hunting is returned to the local community. Much game is claimed by the state for sale and export. Hunting is on the basis of 4,500 reviers or management units, 7,500–25,000 a. in size, which comprise 90 percent of the total land area. Each is leased (for 10 yr.), managed, and hunted by a definite hunting circle, of 10 to 50 members. A shooting plan governs all activities on each revier for the year. The hunters are trained and examined by the state-sponsored Hunting Society, to which they must belong. There are 37,000 licensed hunters (0.12 percent of the population), of whom 7,000 also have deer licenses. Hunting and management are derived from the system of estates and aristocratic hunting traditions. Statistics for kill and export are given, and some comparisons

made with West Germany and the United States.

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EVALUATING THE USE OF AERIAL NESTING PLATFORMS BY CANADA GEESE[1]

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In 1953, we began a long-range population study of Canada geese (*Branta canadensis*) in the Flathead Valley, Montana. We were working with a relatively small breeding population with clearly defined geographic limits described by Geis (1956). We believed that during the course of this intensive study we could test the value of artificial elevated platforms as nesting sites for geese by recording changes in the nesting habits of the population induced by the platforms.

Yocom (1952) showed that Canada geese will nest in artificial platforms and indicated that such platforms could be used to increase the number of Canada geese nesting in a given area. Yocom, however, did not present data to support his contention that artificial nests increased the total number of nesting Canada geese and improved the welfare of geese in the area. Such information is necessary before the use of platforms can be precisely evaluated as a management practice. The purpose of this paper is to present such an evaluation. To do this, a frame of reference had to be established prior to the erection of nesting platforms. Also the nesting histories of geese using the platforms had to be followed from year to year while changes in nesting habits of the population were recorded.

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To determine the value of aerial platforms for goose nesting, we sought answers to the following questions:

1. Is there a progressive increase in use of platforms from year to year?

2. Will geese shift from using natural elevated sites such as osprey or heron nests to using platforms?

3. Is there a percentage increase in the

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use of all aerial goose-nesting sites, including platforms, when platforms are made available?

4. Will platforms induce geese to change from ground to aerial nesting sites, from islands to lake and river shore lines, from island ground sites to island elevated sites?

5. Will nesting platforms increase the total nesting population by providing desirable nest sites where none previously existed or by attracting migratory geese to settle?

6. Will geese nesting in elevated platforms show a higher reproductive rate, better hatching success, and fewer nest failures than ground-nesting geese?

7. How are aerial platforms selected by geese and what is the pattern of use?

8. Is there considerable mortality of goslings when leaving elevated sites?

Two standards were used to compare data and to evaluate the effects of aerial platforms on the Canada goose population. One was population data obtained prior to the erection of platforms. This included number of nesting pairs, number of nests, nest-site locations, total eggs laid and hatched, and mortality during the nesting period (Geis, 1956). The second standard was a 6-yr. average of the same type of data, involving 1,267 nests. The number of nests annually under observation varied from a low of 160 to a high of 296. Each year very nearly all nests in the population were kept under observation; thus the totals shown in Table 1 are not samples but represent closely the total number of nests comprising the population for each of the 6 years.

In this way changes in the population unit caused by the introduction of artificial nesting platforms for any one of 5 years could be compared against the original 1953 situation, against a 6-yr. mean, and against progressive changes from year to year.

The study area included Flathead Lake, which is approximately 30 mi. long and averages 8 mi. in width, a 50-mi. stretch of the Flathead River and the Flathead Valley south of Flathead Lake.

METHODS

In 1954, we erected artificial platforms along Flathead Lake, in Nine Pipe Reservoir, and along the Flathead River, Montana. Platform elevations varied from 4 to 45 ft. Platforms were placed on rock islands, in cattail marshes, and on heavily timbered shore lines, where nesting density was heavy as well as where few or no geese were nesting. Forty-five platforms were on small islands, 21 on large islands and 17 on shore lines. Over a 5-yr. period an average of 73 of the original 83 platforms were available each year to nesting geese. Fifty-three percent were at heights of 3 to 10 ft., 30 percent were at heights of 11 to 20 ft., and 17 percent were at heights of 21 to 45 ft. (Fig. 1).

The platforms were 30 in. long by 26 in. wide by 6 in. deep, constructed of wood and securely fastened to trees (Fig. 2). Soil and duff were placed in these so that the geese could make scrapes. Since some platforms were found to be destroyed or in disrepair each season, prior to the establishment of nesting territories the boxes were repaired and replenished with soil and duff. This

FIG. 1. Canada goose nesting platform erected about 20 ft. above the ground on an island in Flathead Lake.

FIG. 2. Platforms must be filled with soil or duff. The goose makes a scrape, lines it with down.

proved to be an essential task if any number of platforms were to be kept attractive to geese. The first 2 years some platforms were camouflaged, others were not. There was no preference for camouflaged sites; consequently they were discontinued.

CHANGES INDUCED BY ARTIFICIAL PLATFORMS

In 1953, prior to the erection of platforms, 96 percent of 225 nests were located on islands; 93 percent of these were ground nests (Table 1). With this information as a basic frame of reference, data gathered over a 6-yr. period involving 1,267 nests showed that the percentage of all nests on islands dropped from 96 percent in 1953 to 92 percent in 1958, with a 6-yr. average of 95 percent. Except for 1954, the decrease was progressive year by year. The percentage of island ground nests dropped from 93 in 1953 to 83 in 1958 and showed a 6-yr. average of 90 percent. This decrease was also progressive year by year. The percentage of nests located on lake and river shore lines increased from 3 to 8 percent, averaging 5 percent for the period. This increase was progressive year by year.

These changes in location and distribution of goose nests by habitat over a 6-yr. period (Table 1) show that the nesting platforms caused definite and measurable changes in the nesting habits of the goose population.

Shore line ground nests showed no essential change, and no progressive pattern during the 6 years (Table 1).

The use by geese of natural elevated sites such as nests of ospreys, red-tailed hawks, eagles, and herons showed no essential change. The 6-yr. average showed a 1 percent decline over the 1953 standard, but there was considerable variation from year to year with no recognizable pattern (Table 1). Successful defense of nest structures by ospreys, eagles, herons, and red-tailed hawks during some years and inability to deter geese from using these at other times probably accounted for the varied use pattern.

The percentage of all nesting geese in the population that used nesting platforms increased progressively from 1 percent in 1954, when platforms were first erected, to 9 percent in 1958. The percentage of all nesting geese that used elevated nest sites, including platforms and natural structures, increased from 5 percent in 1953 to 18 percent in 1958. The actual increase in use was 11, 15, 13, 15, 23, and 30, respectively, or an increase of nearly 3 times the 1953 standard (Table 1). Since there was no essential change in the number of natural structures used, this increase in use of all elevated sites by the goose population could not have been a shifting from natural elevated structures to the artificial nesting platforms. The percentage of geese in the population that used aerial sites for nesting thus increased nearly threefold as a result of the platforms. This indicates that geese recognized the aerial platforms as desirable nest sites.

Table 1 shows that very few geese in the population unit made ground nests on the lake and river shore lines and that of this number, two-thirds used natural elevated sites. When artificial elevated platforms were made available along lake and river shore lines, geese were induced to use these areas to a greater extent. Supporting this conclusion is the 10-percent decrease of island ground nests from 1953 to 1958 with a corresponding increase of lake and river shore line nests from 3 to 8 percent during the same period.

TABLE 1.—DISTRIBUTION OF CANADA GOOSE NESTS BY HABITAT, FLATHEAD VALLEY, MONTANA

Nest Sites	AREA TOTALS						6-Year Total	6-Year Percent
	1953	1954	1955	1956	1957	1958		
Island nests								
All nests	216	246	282	152	151	155	1,202	
Percent	96	97	95	95	92	92		95
Ground nests only	210	236	275	142	137	139	1,139	
Percent	93	93	93	89	84	83		90
Lake and river shore line nests								
Number	7	7	12	8	13	13	60	
Percent	3	3	4	5	8	8		5
Ground nests only	2	2	6	3	4	1	18	
Percent	1	1	2	2	2	0.5		1.5
Tree nests								
Number	11	10	5	3	9	12	50	
Percent	5	4	2	2	6	7		4
Cliff nests								
Number	0	2	2	1	1	2	8	
Percent	0	1	1	1	1	1		1
Nesting platforms								
Number	Not	3	6	11	13	16	49	
Percent	erected	1	2	7	8	9		5
Total elevated nest sites								
Number	11	15	13	15	23	30	107	
Percent	5	6	4	9	14	18		8
Marsh nests								
Number	2	1	2	0	0	0	5	
Percent	1	5	1	0	0	0		0.5
Totals	225	254	296	160	164	168	1,267	

STATISTICAL EVALUATION

We have attempted to answer two basic questions:

1. Is there a difference in nest-site choice when platforms are available?
2. Can the difference be attributed to nesting platforms?

Making decisions in the face of uncertain evidence is the province of statistical inference. We know that tradition is strong in Canada geese and that established ground-nesting habits are not easily broken. We assume, however, that there are random unexplained variations in nesting habits of geese, that these variations result in somewhat different nesting habits from year to year, and that these variations make Chi-square tests appropriate. Since we cannot predict with any certainty what the geese would have done if platforms had not been erected, we have applied statistical analysis to the first four questions posed.

1. There was a progressive increase in use of platforms from year to year. This was significant at the 99-percent level ($x^2 > 15.68$ at 5 d.f.).

2. The progressive use of the platforms did not significantly affect the use of natural elevated sites ($x^2 = 9.25$; $x^2 = 11.07$ would be significant at the 95-percent level at 5 d.f.). The inference is that the use of platforms was not a shift from natural elevated sites to platforms. Thus the platforms were responsible for increasing the total number of pairs using aerial structures for nesting.

3. The increase in use of all elevated sites over ground nests was highly significant ($x^2 > 33.96$ at 5 d.f.) and indicates that some geese recognized the aerial sites as being more favorable than ground sites.

4. The change from island ground nests to island elevated nests was highly significant ($x^2 > 17.70$ at 5 d.f.). All evidence indicates this change was induced by platforms.

The decrease in island nesting and corresponding increase in use of shore lines was not statistically significant ($x^2 = 10.71$ at 5 d.f.), but a trend is evident.

Forty-one percent of all platforms erected along lake and river shore lines were used as nesting sites by geese; however, evidence of increase in use of lake and river shore lines for nesting, due to availability of aerial platforms, is not conclusive ($x^2 = 10.88$ with 5 d.f.). But again a trend is apparent.

The large Chi-square values indicate that something other than chance changed the nesting habits; we attribute these changes to the presence of nesting platforms.

USE RELATED TO HEIGHT AND HABITAT

Thirty-six percent of platforms erected at 3- to 10-ft. elevation were utilized by geese for nesting; 28 percent of those at 11 to 20 ft. were used, and 57 percent at 21 to 45 ft. There appeared to be a definite preference for the higher sites, especially when these were on lake and river shore lines. Platforms at lower heights were more readily utilized on islands, especially the small islands. Craighead and Craighead (1949), Geis (1956), and others have shown that Canada geese have a strong preference for nesting on islands. A wide variety of nesting cover was used by the 1,267 nesting pairs observed in this study, but plant cover did not appear to be an important factor in nest-site selection. For the purposes at hand we can, therefore, disregard cover in relation to nesting habitat and classify nest sites into three major habitat categories: small islands, large islands, and lake and river shore lines.

To compare the utilization of platforms by habitat we must consider the density of nesting geese in these three major habitat categories. On the small islands, 1 to 6 a. in extent, nesting density was greatest, averaging 5 nests per acre in 1953 and 1954 (Geis, 1956). Theoretically, at least, there was greater opportunity for a platform to be used, but only 31 percent of the platforms placed on small islands served as nests for geese. On the large islands, averaging 20 to 30 a. and larger, where nesting density was ½ nest per acre, 43 percent of the platforms were used. Along lake and river shore lines, where only 3 percent of the entire goose population nested in 1953, 41 percent of all platforms were used. There was no relationship between the use of platforms and the density of nesting geese where the platforms were erected. Quite different results might occur where nesting density is at a high level and competition for sites greater. We can conclude that in the Flathead Valley platforms were utilized by geese at all heights and in all major habitats, but platforms placed more than 20 ft. above ground and those on large islands and lake and river shore lines proved most attractive.

EFFECT ON POPULATION LEVEL

In 1953 there were 200 nesting pairs in the Flathead Valley study area, with an increase to 216 and 285 in 1954 and 1955 respectively. The population then dropped sharply in 1956 to 154 nesting pairs and remained at that level through 1958. This reduction was largely attributed to overshooting.

Any effect the nesting platforms might have had on population level was masked by the drastic changes caused by hunting pressure. There is no evidence, however, that nesting platforms did or will induce more geese to nest by attracting birds from other population units. We have evidence that nesting during most years is confined almost exclusively to locally reared geese and that tradition, breeding age, migration, survival of adults and subadults, and behavior patterns are probably more important than nest sites in determining population level. Nevertheless, it is conceivable that nesting platforms might increase the population level where a population is not heavily harvested and where suitable nesting sites are a limiting factor. This situation does not exist in the Flathead Valley.

TABLE 2.—USE OF NESTING PLATFORMS BY CANADA GEESE, FLATHEAD VALLEY, MONTANA

	AREA TOTALS					5-Year Total	5-Year Average
	1954	1955	1956	1957	1958		
No. of platforms	66	71	78	75	76	366	73
No. platforms showing goose use[1]	15	33	14	15	13	90	18
Percent platforms showing goose use	22.7	46.5	17.9	20.0	17.1	—	24.6
No. platforms used for nesting	3	6	11	13	16	49	—
Percent platforms used for nesting	4.5	8.5	14.1	17.3	21.1	—	13.4
Total no. eggs	14	33	60	77	79	263	—
Average no. eggs per nest	4.67	5.50	5.45	5.92	4.94	—	5.37
No. successful nests	0	6	6	12	11	35	—
Percent nests successful	0.0	100.0	54.6	92.3	68.8	—	71.4
No. eggs hatched	0	31	31	60	56	178	—
Percent eggs hatched	0.0	93.9	51.7	77.9	70.9	—	67.7
No. deserted nests	3	0	3	1	4	11	—
No. nests lost to predation	0	0	0	0	1	1	—
No. nests lost to other causes	0	0	2	0	0	2	—

[1] Includes platforms used for loafing spots and those where scrapes were made but does not include platforms where nesting occurred.

In 1955, when the nesting population was 285 pairs, only 6 out of 71 (8.5 percent) of the platforms were used for nesting. In 1958, with a nesting population of 159 pairs, 16 out of 76 platforms (21 percent) were used.

Nesting habitat conditions remained remarkably constant over the years and no relation could be drawn between use of nesting platforms and spring runoff conditions, high water periods, or weather conditions. The degree of use was directly related to time. Progressively greater utilization of platforms occurred from year to year; this amounted to 3, 6, 11, 13, and 16 from 1954 to 1958. The increase in use rose from 4.5 percent in 1954 to 21 percent in 1958 with a 5-yr. average of 13.4 percent (Table 2).

EFFECT ON REPRODUCTIVE RATE AND NESTING SUCCESS

The fact that geese showed a preference for artificial nesting platforms and other elevated sites when these were available suggests that such sites may increase productivity. This can be tested by comparing reproductive rate, hatching success, and percentage of nests successful of those geese using nesting platforms with similar data obtained for the entire population unit.

Over the 6-yr. period, 1,105 pairs of nesting geese (where clutch size was known) produced 5,739 eggs for a reproductive rate of 5.19 eggs per breeding pair. The 49 pairs of geese using nesting platforms during a 5-yr. period produced 263 eggs for a reproductive rate of 5.37 eggs per breeding pair. The ninety-five percent confidence interval for differences in average number of eggs per nest is -0.48 to $+0.84$. There is thus no strong evidence that platforms directly affected the number of eggs per nest. The 1,113 pairs, for which we have complete hatching data, produced 3,408 goslings for a hatching success of 3.06 per pair of adults, whereas the 49 pairs nesting in platforms produced 172 goslings for a hatching success of 3.63. The ninety-five percent confidence interval for difference in average number of goslings per nest is 0.03 to 1.11—evidence that hatching success increased with use of platforms.

One nesting platform placed 25 ft. high in a ponderosa pine on Bull Island in Flathead Lake was occupied 6 consecutive years (1955 through 1960), with 100-percent hatching success. During this period 36 eggs were laid and 36 goslings hatched. There was no indication of mortality occurring during the descent. Whether the same pair of geese utilized the platform each year is not known.

Over a 6-yr. period 65 percent of 1,163 known-fate nests were successful, whereas

71 percent of nests in platforms were successful during a 5-yr. period ($x^2 = 0.603$ at the 95-percent level with 1 d.f. and is not significant).

CAUSES OF NESTING FAILURE

The major causes of nesting failure were predation and desertion (Table 3). Desertion that occurred before predation took place could not always be detected; thus desertion as a primary cause of nesting failure may be greater than the figures suggest. On the other hand, there is evidence that some mammalian predation may cause desertion but leave the nest and eggs intact. A striking effect of the nesting platforms is revealed by data on cause of nesting failure (Table 3).

In the population unit, desertion accounted for 28 percent of nesting failures over the 6-yr. period. Desertion among geese using the platforms was considerably greater and represented 79 percent of all failures during a 5-yr. period.

Predation was the major cause of nest failure in the population unit, accounting for 247 failures out of 404 or 61 percent. However, only one platform nest was known to have been destroyed by predation; this represented 7 percent. Chi-square tests show that the decreased predation in platform versus non-platform nests is significant at the 99-percent level ($x^2 = 5.74$ with 1 d.f.). When desertion and all other causes of nest failure are compared for platform and non-platform nests, $x^2 = 18.47$ at the 99-percent level and 1 d.f. This is highly significant and indicates that platforms were probably largely responsible for the increase in desertion.

Other causes of nest failure in the population unit and among geese using the platforms showed no noticeable difference, 11 and 14 percent respectively being lumped in this category.

It appears that the exposed position of many of the nest boxes invited greater desertion but greatly reduced predation by the added security of an elevated site. Much of the desertion could be attributed to the disruptive influence of fishermen and sightseers who frequently passed close to the exposed nesting platforms in Flathead Lake or upon occasion inspected them at close range. There is little doubt that this human interference could be reduced by selecting more secluded sites.

TABLE 3.—NEST FAILURES

Cause of Nesting Failure	Population Unit		Platforms	
	Number	Percent	Number	Percent
Desertion	113	28	11	79
Predation	247	61	1	7
Other causes	44	11	2	14
Total	404		14	

We can thus state, in answer to questions 5 and 6, that there was no positive evidence that platforms increased the total nesting population by increasing nest sites or by attracting migratory geese; but the geese using platforms showed a slight increase in reproductive rate, significantly better hatching success, and a higher percentage of nests successful.

The nesting boxes increased desertion as a cause of nest failure, but reduced predation. Since, as we have shown, hatching success increased with use of platforms, increased desertion did not compensate for decreased predation. We can conclude there was a significant net gain in goslings hatched. Furthermore, we believe the loss from desertion can be reduced by more selective placement of the nesting platforms.

SELECTION OF AERIAL PLATFORMS

We had hoped to determine under what conditions nesting platforms were selected as nest sites, and the age and sex of the geese involved. From 1955 through 1958, 548 goslings were color-marked with this purpose in mind. However, an average of only 15 percent of the marked geese were present and recognizable in the population at the end of the first year of life. We know a very small number lost neck markers, some may have moved to other population units, but heavy mortality from hunting accounted for most of the 1-yr.-old birds that did not return. Those marked which attained sexual maturity were considerably

fewer than those surviving 1 year, and did not provide an adequate sample to work with. It may be significant that of the three color-marked known-age geese using elevated nest sites (two in platforms and one in an osprey nest), all three were 3-yr.-old birds for which our records indicate nesting for the first time. We have no record of a marked goose abandoning an established nest site of former years and then selecting a platform. We have much evidence both among marked and unmarked geese that change of nesting area is not a common practice and probably normally occurs only when the initial site has proved unfavorable. Flooding and predation seem to be major factors causing such changes. As pointed out earlier, geese used a higher percentage of nest platforms on lake and river shore lines and on large islands than those on small islands, and showed a preference for the higher sites; this we believe is largely a response to the threat of predation.

More information is needed on this point and can be obtained only from marked known-age birds. It would be particularly valuable from the standpoint of management to determine to what extent unsuccessful nesters select and use aerial platforms. Preliminary evidence from unmarked birds indicates this may happen. It seems probable that both learning (Thorpe, 1951) and social facilitation (Crawford, 1939) are involved. The authors propose to discuss this in greater detail in a paper on tradition and nest site selection.

A pair of geese tend to return to the same nest site year after year. This tradition has an important effect on the population level and on the distribution of nest sites; it appears to be so basic that, once established, it is not quickly altered by the attraction of elevated nesting platforms.

PATTERN OF PLATFORM USE

Of 75 platforms erected and available to geese for 1 year or longer, 30 were used as nests. Some platforms were used the first year they were constructed while others were not utilized until the fifth year. The pattern of first use was first year 3, second year 8, third year 8, fourth year 3, and fifth year 8. Each year additional platforms were used by geese and some previously used ones were vacated. Eighteen platforms were used only 1 year, 8 were used 2 years, 3 used 3 years, and 1 was used for 6 consecutive years.

After termination of the intensive phase of the study, the artificial nesting platforms were checked for occupancy during 1959 and 1960 to determine if use decreased as unrepaired platforms became untenable. In spite of a reduction in the number of platforms available and/or suitable for nesting, 12 platforms were occupied in 1959 and 13 in 1960. This represents a 25 and 19 percent reduction respectively over the peak year of 1958 (Table 2). The number of natural aerial structures used during these years was 9 and 11 respectively and thus showed no marked change from the situation that existed from 1954 through 1958. We believe the decrease in use of platforms was directly related to their disrepair. To obtain maximum use by geese, platforms should be repaired and filled with soil or duff each year.

MORTALITY OF GOSLINGS DESCENDING FROM AERIAL NESTS

One hundred and seven nests, or 8.4 percent of 1,267 nests, under observation were in elevated sites. (This does not include 45 aerial nests recorded in 1959 and 1960.)

Observation at many of the 107 aerial nests yielded only one incident where a gosling was killed in making the descent. A sharp stick protruding from the sand impaled the gosling when it struck the ground. Craighead and Stockstad (1958) reported an observation of goslings leaving an elevated nest. Since then the senior author and Ralph Stockstad made a second observation of this interesting behavior, and a third was reported to us by Maurice Hornocker. These bear accounting since they shed further light on the survival of goslings reared in aerial nests.

In one instance in late afternoon a Canada goose was observed on an osprey nest some 80 ft. above the ground. Closer in-

spection showed there were goslings in the nest. Rapping the tree flushed the gander and revealed the goose which hitherto had been concealed in the cup of the nest. It was anticipated that the goose would flush, fly to the water, and call the goslings, and that they would jump as observed on a previous occasion (Craighead and Stockstad, 1958). The goose proved very difficult to dislodge, refusing to leave until the observer had climbed a nearby tree to nest height. The goose left suddenly, and simultaneously with her departure, the three goslings launched themselves over the brink of the nest. All three goslings hit limbs as they fell, but the fall was not effectively broken for any of them. Less than 60 sec. after striking the ground the goslings were carefully examined. None appeared injured. All three could walk and, when taken to the lake shore, swam several hundred yards to join their parents; the family proceeded to swim several miles eastward until lost from sight. The fall sustained by these goslings was as formidable as any that would have been experienced by goslings from the 107 aerial nests under observation. On another occasion six goslings jumped from the top of a dead stub 40 ft. above the ground. One of the six landed on its back in a brush pile and appeared injured, but examination showed no broken bones or external injuries. In about 3 min. it seemed normal and when released swam off to join the goose.

The direct evidence of successful descents is further supported by indirect evidence. We were able to make gosling track counts in sand beneath some tree nests to compare with egg numbers and goslings hatched in these nests. Similarly, counts of 2- and 3-day-old goslings in the vicinity of aerial nests were compared with data on clutch size and hatch. Such data must be interpreted with caution, but the information indicated that most goslings get safely out of aerial nests—even the very high ones.

MANAGEMENT SUGGESTIONS

Artificial nesting platforms can be used effectively in the management of Canada geese, providing the platforms are erected at secluded sites and repaired and replenished with soil and duff each season prior to the establishment of nesting territories. In this study they did not cause an increase in general population level, but brought about a change in nesting habitat that was beneficial to the population.

They should prove most effective if placed on large islands or on lake and river shore lines or wherever suitable nesting sites are limited or where natural sites are subjected to flooding or heavy predation. It is recommended that platforms be constructed as described in the methods section, but any large platform securely fastened and filled with soil will suffice. The structures should be placed 20 to 50 ft. above the ground, preferably at isolated sites so as to minimize desertion.

SUMMARY

During a 5-yr. period 73 aerial platforms, on an average, were available each year to Canada geese. One hundred and seven aerial nests of all types were observed; 49 of these were located in the aerial platforms and 58 in natural elevated sites. Since there was no decrease in the use of natural aerial structures during this time but a decrease in ground nests did occur, it was concluded that the platforms caused a greater number of geese to select aerial sites. The percentage of all nesting geese in the population that used nesting platforms increased progressively from 1 percent in 1954, when platforms were first erected, to 9 percent in 1958. The use of all elevated nest sites, including platforms and natural structures, increased from 5 percent in 1953 to 18 percent in 1958. There was no evidence that the nesting platforms increased the number of geese nesting in the study area. However, platforms caused significantly measurable effects in nest-site selection, mortality factors, and hatching success. Use of platforms caused a decrease in island ground nests and an increase in island aerial nests. A general decrease in island nesting and a corresponding increase in use of lake and river shore lines, though not statistically

significant, showed a trend and is believed to be due to use of platforms. Supporting this belief is the fact that 41 percent of all platforms erected along shore lines were used as nesting sites. Geese using aerial platforms showed a slight increase in reproductive rate, significantly better hatching success, and a higher percentage of nests successful. The platforms significantly increased desertion as a cause of nest failure, but significantly reduced predation. This was not compensatory as there was a net gain is goslings hatched. Gosling mortality incurred while getting out of elevated nests was negligible. It is concluded that construction of aerial platforms benefited the geese, but to be most effective, platforms should be rehabilitated annually, erected 20 to 50 ft. above the ground, and located in situations remote from human activities.

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THE EFFECT OF PAIRING ON COOING OF PENNED MOURNING DOVES[1]

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The objective of this study was to measure quantitatively the effects of pairing, position in the nesting cycle, and weather factors on the frequency of cooing of penned mourning doves (*Zenaidura macroura*). Information thus derived may provide a biological basis for judging the efficacy of using dove song as an index to abundance.

The dove call count, originated by McClure (1939), has been favored by many workers over other sampling techniques such as random and controlled road counts, and nest counts (McGowan, 1952, and other authors whose reports appear in U.S. Fish and Wildl. Serv. Spec. Sci. Rept. No. 17). Use of the call count as a standard technique extended to 44 states by 1955 (Southeastern Assn., 1957).

As standardized, the call count begins at ½-hr. before sunrise and continues for 2 hr. The observer listens for 3 min. at each of 20 successive stations, located 1 mi. apart. He records the number of different doves heard calling (U.S. Bur. Sport Fish. and Wildl., 1960). The evening call count (no longer used in the standardized call-count census) began 2 hr. before sunset and ended at sunset. In addition, the observer gains supplemental information by tallying both the numbers of doves seen at the listening stations and those seen between stations.

Refinements in the sampling technique were sought by Foote, *et al.* (1958). They concluded that the original call-count routes were often laid out in better-than-average dove areas, and should be replaced with randomly chosen routes. The first published attempt to analyze dove song crit-

[1] Contribution from the Missouri Cooperative Wildlife Research Unit; U.S. Bureau of Sport Fisheries and Wildlife, Wildlife Management Institute, Edward K. Love Foundation, and University of Missouri cooperating.

ically as a population index was by Cohen, *et al.* (1960). They examined the calling of 63 mourning doves in the wild in 2 midwestern life zones and found that "apparently the calling behavior of some birds in 3-min. intervals can be considered to be random while for other birds it cannot." They concluded that "the mourning dove calling pattern may be a physiologic-behavior mechanism related to the court-mate-nest-brood cycle. . . . The calling pattern of an individual mourning dove apparently depends upon the time of season . . . time of morning, weather and probably upon sex ratio in the surrounding dove population and relative position of the individual in the court-mate-nest-brood cycle."

Similar conclusions on the influence of the nesting cycle were reached by Webb (1949) and Mackey (1954).

As a result of their own findings, L. E. Foote and H. S. Peters suggested the intensive study of cooing behavior of mourning doves which has culminated in this paper. We are indebted to Marian R. Frankel, H. M. Wight, J. E. Randall, and Wm. H. Elder for assistance or advice. Statistical advice was given by the University of Missouri Computer Research Center. The senior author was an Edward K. Love Fellow. The research was supported in part by a grant from the Wildlife Management Institute.

PROCEDURE

The study was made from April 12 to September 5, 1960, near a laboratory located on the Ashland Wildlife Research Area, Boone County, Missouri. Intensive observation was made of three male and five female mourning doves, all pen-reared.

The birds under observation were housed in three experimental pens, each of which was 8 ft. long, 8 ft. high, and 6 ft. wide. All three pens were protected by an electric fence. Pen 1 was 44 ft. from Pen 2. The two pens were within easy audible range of each other, although a corner of the laboratory blocked the view between them. Pen 3 was 80 ft. beyond Pen 2, within audible and limited visual range of both the other pens. Extra females were kept in small holding pens.

The nest structure provided for the birds was a cone-shaped piece of tarpaper, similar to the artificial substrate described by Calhoun (1948). Water, hen scratch, millet seed, and crushed oyster shell were furnished *ad libitum*.

One pair of doves was placed in each pen. Although the males were not transferred during the course of the study, the females were temporarily removed, or transferred at various times.

The observer recorded the time of all dove calls from the penned birds during two daily study periods of 2½ hr. each. The morning study period was from 1 hr. before sunrise until 1½ hr. afterwards. The afternoon study period was from 2 hr. before sunset until ½ hr. afterwards.

The study periods began a half-hour earlier in the morning and lasted a half-hour later in the evening than the standardized call counts. This was done in order to observe the first song in the morning and the last song at night.

Exact records were kept by stopwatch of the time in minutes and seconds of the "perch call." The perch call consists of "a series of three (sometimes four) notes on one pitch, preceded by an introductory note which begins below the sustained pitch, glides up above it, and then down to it . . ." (Craig, 1911). There are actually many variations of this song. However, there is a rhythm in the perch coo, in addition to conditions under which the song is delivered, which labels a particular song as "perch coo" even though "the series of three (sometimes four) notes" become abbreviated. We recorded all perch coos, irregular as they might be, as long as the introductory note and one other note were delivered.

The mourning dove delivers another song, called the "nest call." Craig (1911) wrote:

"The male Mourning Dove, not content with one exquisite lay, sounds also a nest-call which is very different in expression and in its way as perfect as the song. This call is much shorter than the song, and

much fainter, so that the field observer may fail ever to hear it. Its typical form is of three notes, a low, a high, and a low, thus somewhat resembling the first bar of the song, but differing in that the three notes do not glide into one another, there being a clear break from each note to the next."

The penned females occasionally sang the perch call (although much more faintly than the male), and often sang the nest call. Calls of females were excluded from our analysis of cooing performance.

The standard call-count procedure probably results in tallying only perch coos of males. The much lower audibility of the infrequent female perch calls would seem to rule them out, and the instructions to record only complete calls "usually consisting of a preliminary note and three coos" (U.S. Bur. of Sport Fish. and Wildl., 1960) would eliminate nest calls.

Call-count procedures differ from ours because workers making dove call counts are instructed to record primarily the number of doves heard calling. We recorded only the number of calls from a known number of male doves.

Temperature and relative humidity were measured at the beginning, middle, and end of each study period. Weather conditions and cloud cover were estimated periodically. Wind velocity was measured by means of a cup anemometer, mounted at a height of 8 ft.

Readings of barometric pressure were secured from the United States Weather Bureau, located at the Columbia Airport, 17 mi. from the laboratory.

PEN HISTORIES

Detailed pen histories are necessary in order to evaluate the results of this experiment.

Pen 1 History

Original pair was Pen 1 male and female A. Birds deserted eggs laid April 25–27. Experimenter removed female A on May 8; male responded with great increase in cooing. Female A was color-marked and returned May 17, but male would no longer accept her. On May 22, female A from Pen 1 and female B from Pen 2 were exchanged. New pair in Pen 1 were compatible. Eggs laid May 24–26 and May 31–June 2 deserted almost immediately. Eggs laid June 7–9 incubated, mainly by female; eggs hatched June 22–23, brooding and feeding mainly by female; young fledged July 5. Eggs laid July 8–10 deserted immediately. Female removed July 10, and male responded with heavy perch calling. Female replaced July 13, eggs laid July 18–20, incubated, with both male and female participating. Squabs hatched August 2, brooded by both birds, fledged August 13. Intermittent courtship from August 13–September 3, after which female B was removed for final check of unmated male. Pen 1 male did not respond with song. Study of this pair ended September 5.

Pen 2 History

Original pair was Pen 2 male and female B. Eggs laid April 14–17, immediately deserted. Female B was removed May 4, and male responded with great increase in cooing. Female replaced May 8, eggs laid May 12–14 deserted immediately by male, later by female. Females A and B exchanged on May 22, and male did not accept female A. On May 31, female A was removed, and female C introduced, but not accepted by male. June 6, female C removed, female D introduced, but not accepted by male. June 17, female D removed, female C re-introduced and pair bond finally formed. Eggs laid June 25–27. These eggs were not incubated by either bird, nor was single egg laid July 2 incubated, nor the pair of eggs laid July 7–9. Female C removed July 13 and male responded with great increase in perch calling. Female replaced July 15, egg laid July 21, ignored by both birds. Female C removed for few minutes on July 22, color-marked on head, and returned. Pair bond was destroyed, male responded with great increase in perch cooing. Study of this pair ended July 27.

Pen 3 History

Original pair was Pen 3 male and female E, and there were no changes in pair during study. Eggs laid April 18–20, incubated by both birds, young died upon hatching, May 1–2. Eggs laid May 5–7, normal incubation by both birds, predator took eggs May 19. Single egg laid May 28, incubated by both birds; predator took egg June 2. Experimenter transferred eggs from Pen 1 to Pen 3 nest, pair incubated these eggs until June 13 (3 days past time pair would have incubated single egg) when both deserted nest. Female E removed June 13, male responded with great increase in perch calls. Female replaced June 15, eggs laid June 18–20; both birds incubated, eggs hatched July 3–4; both birds brooded, squabs fledged July 13. Female E removed July 18, male responded with great increase in perch calls. Female replaced July 20, eggs laid July 25–27; both birds incubated, eggs hatched August 9–10; squabs fledged approximately August 18–20. No further nesting activity, August 20–September 3, when female E

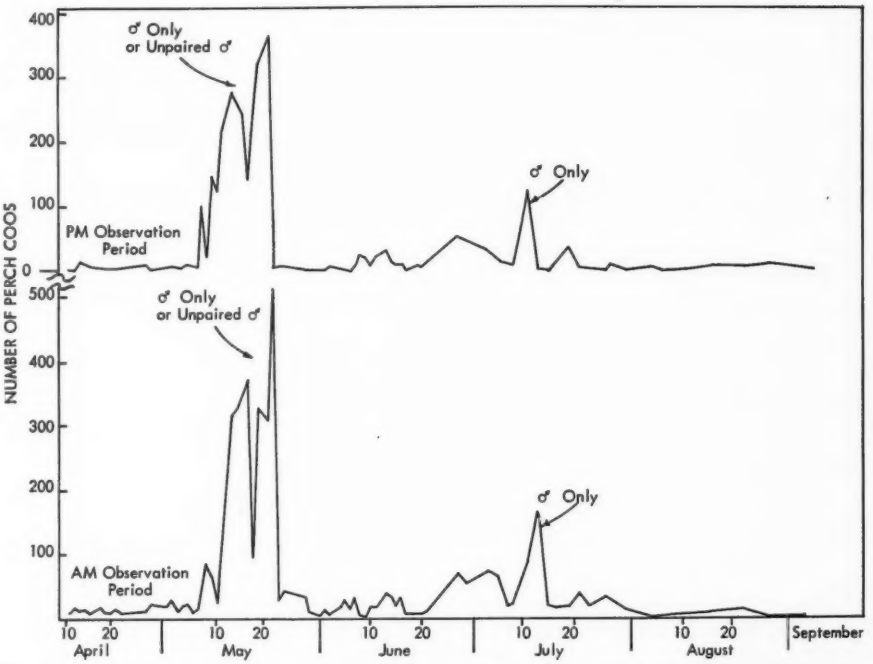

FIG. 1. Cooing frequency of Pen 1 male during 2½-hr. observation periods (morning, 77 observations; afternoon, 71 observations).

was removed. Male did not respond with song. Study of this pair ended September 5.

RESULTS

The following conclusions may be drawn from examination of Figs. 1, 2, and 3 in light of the pen histories:

1. In any one pen, cooing showed the same daily trend in morning and afternoon, although afternoon cooing was at a lower frequency.

2. When the female was removed from a pen, cooing increased sharply. When the female was returned, cooing immediately dropped to the previous level.

3. If the female was in the pen, but for some reason a pair bond had not been formed, cooing of the male appeared to be as high as if the female were absent. This may be seen in Figs. 1 and 2, in which the peaks are designated as "unpaired male."

4. Cooing appeared to drop off in August. By September 5, males in Pens 1 and 3 did not respond with cooing when females were removed.

5. There were no obvious differences in cooing frequencies during various stages of the nesting cycle.

Effect of Breeding Status on Cooing

The sharp difference in cooing frequency between mated and unmated males is shown in detail in Table 1. In the table, the term "mated status 1–4" refers to observations made of the male while in all stages of the nesting cycle; "unmated status 5–6" refers to observations of the male while he was not mated. Specific status classifications are as follows:

Status 1. Birds show signs of courtship and nest building.

Status 2. Egg laying—the period from

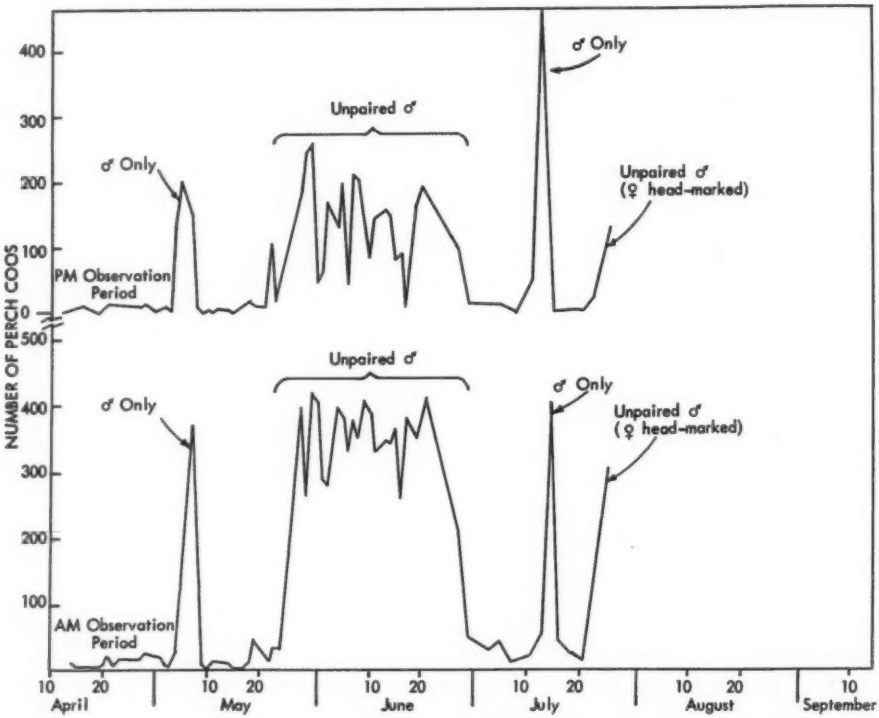

FIG. 2. Cooing frequency of Pen 2 male during 2½-hr. observation periods (morning, 65 observations; afternoon, 60 observations).

appearance of first egg until second was laid.

Status 3. Incubation—the time from the laying of last egg of clutch until first egg was hatched.

Status 4. Brooding—the time from hatching of first egg until nestlings left nest.

Status 5. Male only—the result of deliberate removal of female for varying periods of time.

TABLE 1.—COMPARISON OF COOING FREQUENCY OF MATED AND UNMATED DOVES

Pen No.		Perch Coos for 2½-hour Period			
		Mated Status 1–4 a.m.	Unmated Status 5–6 a.m.	Mated Status 1–4 p.m.	Unmated Status 5–6 p.m.
1	Mean	20.2(61)[1]	222.3(12)	8.3(54)	190.6(13)
	Std. dev.	15.4	155.0	11.4	95.2
2	Mean	17.7(34)	314.7(31)	7.7(29)	143.3(31)
	Std. dev.	14.8	104.9	9.2	87.1
3	Mean	24.0(64)	171.9(2)	17.3(63)	231.0(2)
	Std. dev.	16.3	11.3	13.9	29.7

[1] Numbers within parentheses represent number of observations of each male while in specified status.

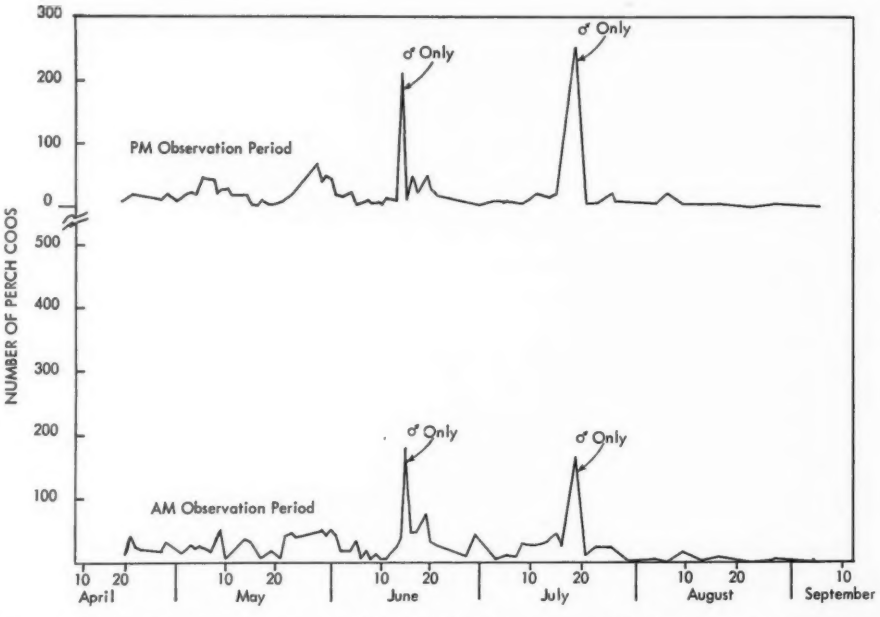

FIG. 3. Cooing frequency of Pen 3 male during 2½-hr. observation periods (morning, 69 observations; afternoon, 68 observations).

Status 6. Unpaired—male and female together in pen, but not mated.

While mated, Pen 1 male cooed most frequently in Status 4, both morning and afternoon (Table 2). The Pen 2 male never reached brooding status. While mated, he cooed most in Status 1, both morning and afternoon. The Pen 3 male, while mated, showed a peak during morning observations in Statuses 1 and 2; but in afternoon performance, showed a high in Status 2. If Status 2 is disregarded in the afternoon counts because of its low sample size, then both Statuses 1 and 3 are close seconds.

Statistical analysis was made of the differences in cooing frequencies according to breeding status. Performance of each male was analyzed separately, and sample number is therefore the number of observations of each bird. Of 30 t tests, there were only 7 in which there was found a significant difference at the 5-percent level between the coo counts in different breeding statuses:

1. Pen 2 male, afternoon observation period, between Status 1 and Status 3 ($t = 2.656$, $n = 19$, $.01 < P < .02$).
2. Pen 2 male, morning observation period, between Status 1 and Status 2 ($t = 2.615$, $n = 19$, $.01 < P < .02$).
3. Pen 3 male, morning observation period, between Status 1 and Status 3 ($t = 2.328$, $n = 30$, $.02 < P < .05$).
4. Pen 3 male, morning observation period, between Status 1 and Status 4 ($t = 3.030$, $n = 19$, $.001 < P < .01$).
5. Pen 3 male, afternoon observation period, between Status 1 and Status 4 ($t = 2.221$, $n = 18$, $.02 < P < .05$).
6. Pen 3 male, afternoon observation period, between Status 2 and Status 4 ($t = 2.959$, $n = 5$, $.02 < P < .05$).
7. Pen 3 male, afternoon observation period, between Status 3 and Status 4 ($t = 2.777$, $n = 14$, $.01 < P < .02$).

These data do not justify the conclusion that there is a difference in cooing as a

TABLE 2.—ANALYSIS OF CALL COUNTS IN 2½-HOUR PERIOD FOR THREE PENNED MALES IN DIFFERENT BREEDING STATUS

	MATED STATUS				UNMATED STATUS	
	1	2	3	4	5	6
Pen 1 (a.m.)						
Mean	17.2(32)[1]	15.6(7)	21.4(14)	34.4(8)	178.6(8)	309.8(4)
Std. dev.	7.2	13.2	11.4	33.5	136.7	171.1
Pen 1 (p.m.)						
Mean	3.6(26)	12.9(6)	9.2(16)	22.7(6)	160.8(9)	257.8(4)
Std. dev.	3.4	14.1	8.0	23.4	81.0	100.6
Pen 2 (a.m.)						
Mean	21.3(21)	11.0(2)	12.0(11)		292.8(4)	318.0(27)
Std. dev.	15.6	2.8	12.6		112.0	105.7
Pen 2 (p.m.)						
Mean	8.2(15)	5.8(5)	7.9(9)		236.8(4)	129.4(27)
Std. dev.	11.9	5.1	5.9		151.4	67.6
Pen 3 (a.m.)						
Mean	31.6(14)	32.4(7)	21.2(35)	15.5(8)	171.0(2)	
Std. dev.	13.4	21.8	15.8	11.1	11.3	
Pen 3 (p.m.)						
Mean	15.8(15)	39.0(5)	16.5(37)	7.5(6)	231.0(2)	
Std. dev.	10.5	23.1	12.0	6.3	29.7	

[1] Numbers within parentheses represent number of observations of each male while in specified status.

result of different positions in the nesting cycle. Even the few differences that were significant were not consistent among the three birds.

Comparison of Morning and Afternoon Cooing

The higher intensity of cooing during the morning study period, which was indicated in Figs. 1, 2, and 3, is confirmed by analysis of data from Table 1. Pen 1 male cooed 2.4 times as often in the morning as in the afternoon while mated, and 1.2 times as often while unmated. Corresponding ratios for Pen 2 male are 2.3 : 1 and 2.2 : 1, whereas the mated ratio for Pen 3 male is 1.4 : 1. The unmated ratio for Pen 3 male was discarded because only two observations were made.

All reports in the literature agree that the morning cooing is far greater than the afternoon cooing, with the Southeastern Assn. (1957:12) concluding that there is approximately a 4 : 1 ratio.

The cooing in the morning observation periods showed an extremely high linear correlation with the cooing in the afternoon observation periods (Pen 1 male, $r = +.821$, $n = 63$, $P < .001$; Pen 2 male, $r = +.743$, $n = 49$, $P < .001$; Pen 3 male, $r = +.842$, $n = 58$, $P < .001$). Variables compared were the morning cooing with the afternoon cooing (2½-hr. total coo count) of the same bird on the same day. Days in which the female was removed or returned were excluded.

Seasonal Variations in Cooing

A seasonal trend is shown clearly in the singing of the three male doves (Table 3). However, the nature of the trend is not clear. Each bird while mated reached a peak in cooing in a different month; and Pen 1 male reached a peak at a different month in morning cooing from that reached in afternoon cooing. Both Pen 1 and Pen 3 males, which were studied during August and early September, showed the expected decline in song during this period. Neither male responded on September 5, following the removal of the female on September 3.

While these results thus confirm the well-known seasonal diminution in dove song, we did not observe the 30-day "peak sea-

TABLE 3.—SEASONAL CHANGES IN COOING OF THREE MATED MALE DOVES (expressed as mean number of coos per 2½-hr. period)

Month	A.M. OBSERVATION PERIOD		P.M. OBSERVATION PERIOD	
	Mean	Std. dev.	Mean	Std. dev.
Pen 1 male				
April	13.7(13)	4.1	3.2(8)	3.0
May	19.6(13)	10.6	3.7(11)	3.0
June	22.5(20)	17.2	13.7(20)	14.0
July	30.6(11)	19.9	9.7(11)	12.8
August	5.4(7)	4.5	4.1(7)	3.1
September	0.0(1)	—	0.0(1)	—
Pen 2 male				
April	10.9(10)	7.4	7.4(7)	6.0
May	13.4(14)	11.9	5.7(14)	4.5
June	51.0(1)	—	14.0(1)	—
July	28.4(9)	15.7	11.0(11)	17.0
Pen 3 male				
April	24.2(6)	10.4	14.0(5)	4.8
May	28.3(22)	15.9	23.8(23)	17.2
June	26.7(19)	18.7	16.2(19)	13.0
July	19.7(12)	12.9	11.9(11)	6.1
August	3.9(7)	4.8	6.1(7)	5.8
September	0.0(1)	—	1.0(1)	—

son plateau" noted by many students of the call count. This plateau is said to start sometime in May, when the calling is maximum and fairly constant (McGowan, 1952, 1953; Kerley, 1952; Lowe, 1956). The concept of the peak-season plateau is important in the use of the dove call as a population index, because call counts taken during this plateau are considered to be comparable from year to year.

There was no opportunity for study of the seasonal changes in male song while unmated, since the males in the three pens were unmated only occasionally and the shortage in pen-reared males precluded continuous observations of an unmated male. However, the unmated male appears to have a steady high plateau which extends as long as the male is unmated, until the seasonal decline. Thus the possibility appears that the peak season of calling could be really a peak in the proportion of unmated males to mated males in the population. If so, as the proportion of unmated to mated males shifts in favor of mated males, cooing decreases, even though the number of males actually present has not changed. This hypothesis, however, is weakened by the fact that most investigators have found that peak nesting and the peak-season plateau of cooing occur at approximately the same time (McGowan, 1952, 1953; Hopkins and Odum, 1953; Lowe, 1956).

Cooing as a Function of Daily Time

The cooing of mated males began approximately 1 hr. before sunrise, increased in frequency until the peak was reached at about 30 min. before sunrise, and leveled off on a plateau until about 15 min. before sunrise, when the cooing slackened off (Fig. 4). The cooing of Pen 3 male was delayed slightly, increasing in frequency at the eighth 3-min. period (36 min. before sunrise), reaching its peak at approximately the twelfth 3-min. period (24 min. before sunrise) and falling off close to sunrise.

In contrast, cooing of unmated males showed no sharp peak during the morning observation period. A high frequency was attained at about 30 min. before sunrise, after which cooing slowly declined (Fig. 5). Deviation from this pattern by Pen 3 male undoubtedly resulted from the small number of observations. In the afternoon observation periods, there were no marked peaks for either mated or unmated males.

Field studies by Duvall and Robbins (1952), Peters (1952), and McGowan (1952, 1953) agree that calling during the early morning hours is at a peak at or near sunrise. Their description of calling as a function of time therefore is in general agreement with our observations of mated males. Could it be that these investigators were then listening to mated males calling in the wild? An explanation more compatible with our results is that the cooing of the mated males which concentrate their calling near sunrise is superimposed upon the cooing of the unmated males which coo at a high level throughout the morning period. Regardless of the ratio of mated to unmated birds, this would result in a peaked curve, although as the ratio decreases, the base level of cooing frequency would rise.

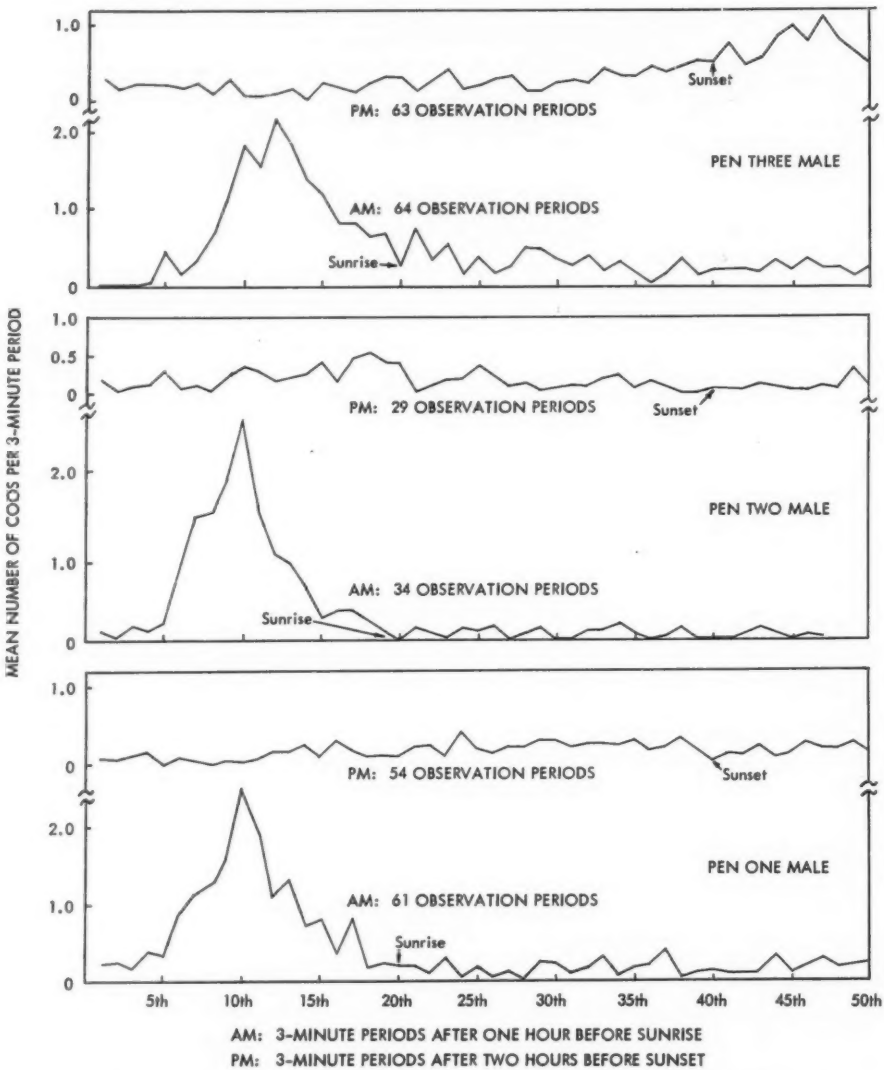

FIG. 4. Cooing frequency of three mated males in relationship to time of day.

Effect of Weather Factors upon Cooing

A linear correlation study was made between the total perch coos in a 2½-hr. period of each male dove and the five weather factors: temperature, relative humidity, barometric pressure, wind, and cloud cover. Statistical significance was set at the 5-percent level. Each weather factor was handled separately, and its relationship evaluated with the daily call count in a mated male,

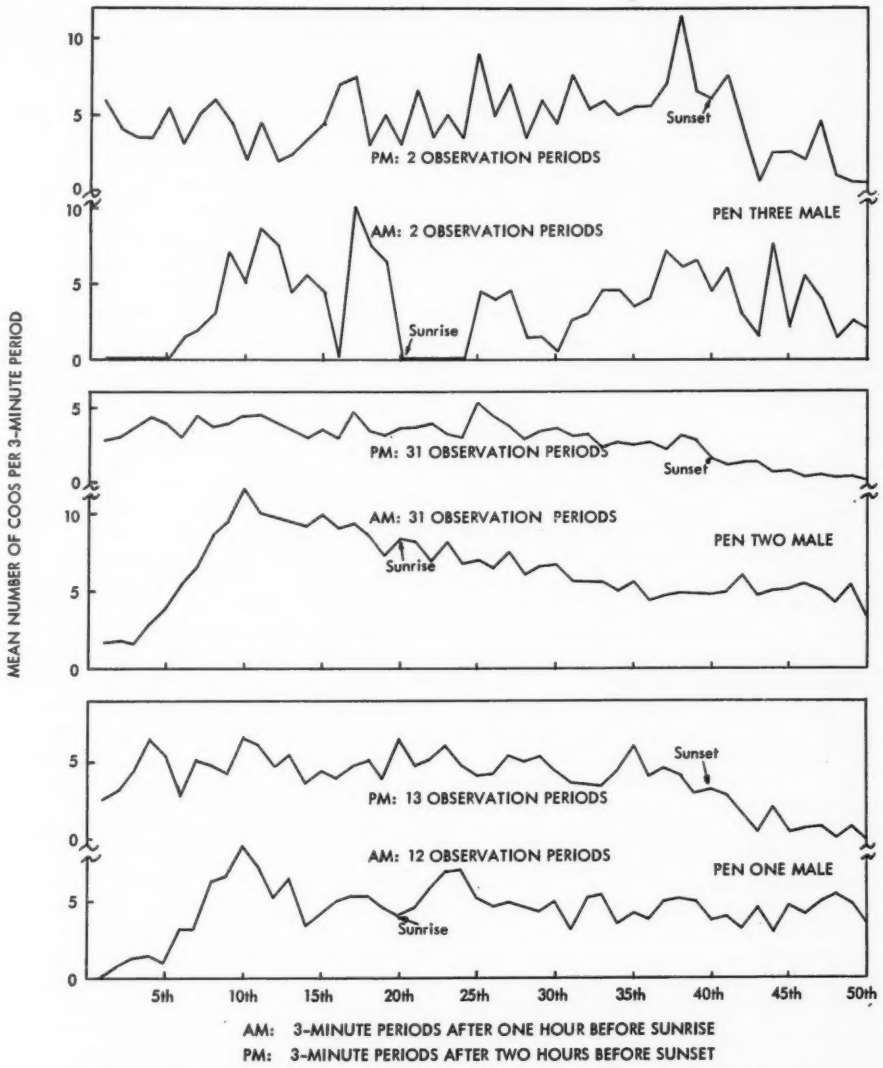

FIG. 5. Cooing frequency of three unmated males in relationship to time of day.

morning and afternoon, and unmated male, morning and afternoon. There was a total of seven significant correlations between weather factors and cooing.

While four of the seven significant correlations were between temperature and cooing, one of the four was negative while three were positive. At the same time, six other possible correlations between temperature and cooing were not significant. The

results of this experiment, therefore, do not justify any generalizations about the effect of weather upon cooing. Possibly cooing behavior is governed by environmental extremes, between which the small daily changes have little effect. This viewpoint has been suggested for temperature by McClure (1939) and Mackey (1954).

DISCUSSION

Four previous studies have dealt particularly with the relation of the dove's song to its life history. McClure (1939) thought cooing activity during the breeding season "was very constant," and that there was a "direct relationship between the number of Mourning Doves present in an area and the number cooing." Webb (1949) tallied calls in an area known to contain 15 to 17 pairs of nesting doves, and found extreme variability in cooing, with many breeding birds remaining silent during the 5-min. observation period at sunrise. Webb noted that male doves cooed more while incubating than while brooding. Mackey (1954) observed two male doves, one mated and one unmated, for 3 weeks, and observed no difference in calling. He concluded after a study of three marked males that perch cooing is cyclic, reaching its peak "during the interval between broods." Cohen, *et al.* (1960) found that the differences in cooing lay within the birds themselves, and suggested that a major influence might be the "court-mate-nest-brood cycle."

The results of the present study cast doubt upon the major importance of position in the nesting cycle on cooing frequency. It is possible to find tenuous support in Table 2 for the thesis that the highest cooing frequency of the mated male is during courtship. Both Pen 2 and Pen 3 males approached their peak during courtship. Pen 1 male cooed heavily during brooding, as a direct result of reopening courtship while the female was brooding. But the cooing frequency of all three males while mated was only approximately one-tenth of that while unmated.

This study indicates that the major influence upon the cooing frequency of a male dove is whether it is mated. If the male is mated and nesting, it coos very little. Even though there may be differences in its cooing frequency in different stages of the nesting cycle, these differences are small and overshadowed by its ebullient performance when unmated.

The inhibitory effect of pairing upon male song has been noted in many birds. It was first mentioned by Montagu, in his Ornithological Dictionary of 1802, according to Lack (1953:39). Montagu observed a decline in the song of the male redstart (*Phoenicurus phoenicurus*) after acquiring a mate, and experimentally showed that when the mate was removed, the redstart would return to full song. Howard (1920) was the first modern writer to emphasize "the partial or complete suspension of the song after pairing." Howard observed that the inhibition was usually temporary, lasting from a few days to a few weeks, in several species of European passerines.

Michener and Michener (1935) reported that the male mockingbird (*Mimus polyglottos*) ceased singing its advertising song upon becoming mated. Quaintance (1938) observed that the male brown towhee (*Pipilo fuscus*) did not sing after becoming permanently mated, and showed experimentally that the introduction of a female to a wild unmated male quickly silenced its song. Lack (1953) described the same inhibition in the European robin (*Erithacus rubecula*), and stated that "in the early spring nearly all the robin song comes from cocks which are unmated."

Tinbergen (1939) described how the male snow bunting (*Plectrophenax nivalis*) stopped singing abruptly upon arrival of a female. Nice (1943) said that after the male song sparrow (*Melospiza melodia*) became mated, "the change from almost constant singing all morning long to 2 to 10 songs an hour or possibly none at all is startling."

If the results of the present study obtain in the field, then a precise interpretation of call-count data requires thorough information on the ratio of mated to unmated male mourning doves. If the call-count

census in succeeding years is taken at periods in which the ratio of mated to unmated birds is vastly different, then the calculated trend from year to year could be in serious error. For this reason, Quaintance (1938) ruled out a song count as a population index to brown towhees, "since the use of song is restricted largely if not entirely to unmated males." Kendeigh (1944) recognized the objections to use of bird song as a population index, because a "sizeable percentage" might be unmated, and males "often reduce their singing or stop altogether" after acquiring a mate. He concluded, however, that the recording of singing males is "essential" to any method of censusing, and suggested that such data be supplemented with other information.

Since results of the present study of penned doves cast doubt on the utility of the call count as an index to dove population, it seems imperative now to test these results in the field.

SUMMARY

Results of this study of penned mourning doves indicate that the major influence upon the cooing frequency of a male dove is whether it is mated. Tenfold increases in frequency of perch coos resulted when females were removed from their mates. When the females were returned, cooing dropped to the previous levels, if pair bonds were restored. No generalizations could be drawn about the effects on cooing of weather factors or position in the nesting cycle. If our results can be extended to the field, then any precise interpretation of call-count data requires information on the ratio of mated to unmated male doves.

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CREATION OF TROUT HABITAT BY CONSTRUCTING SMALL DAMS

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The purpose of this study was to try to create a habitat suitable for trout by deepening the headwaters of Sagehen Creek through the construction of small dams 1 to 2 ft. in height. Located in the northeastern Sierra Nevada of California, this shallow section of Sagehen Creek contained no trout in July 1957 when work was begun. After the dams were built, wild brook trout, *Salvelinus fontinalis* (Mitchill), from a natural population lower in the creek were introduced into the headwaters.

Habitat improvement has long been recognized as a useful tool of wildlife management. Studies evaluating the effectiveness of stream improvement devices have been made in various parts of the United States, especially in Michigan (Hubbs, *et al.*, 1932; Tarzwell, 1937; Shetter, *et al.*, 1949). Warner and Porter (1960) reported the results of building rock deflectors and dams in a Maine stream. Effects of small dams built in the West have been described by Tarzwell (1938) and Cronemiller (1955). Even though these studies indicate that benefits to trout result from stream improvement, relatively little effort has been expended on this phase of management.

Upper Sagehen Creek arises from two permanent springs at an elevation of about 7,400 ft. (Fig. 1). Above these springs the stream is snow fed and intermittent. During this study, water temperatures of the springs varied from 37 to 38°F. throughout the year and the *p*H ranged between 6.7 and 7.1 in July. Five other springs with yearly temperatures between 39 and 46°F. enter the stream lower in the headwater area.

Below the headwater springs the stream twists and turns through 3,600 ft. of interspersed meadow and forest to the lower border of the study area marked by an old road crossing (Fig. 1). This stretch of stream drops 252 ft. (370 ft. per mi.) in elevation and contains 16,280 sq. ft. of surface. Riparian plants consisting of grasses, corn lily, alders, and willows are plentiful in the lower half of the study area but are sparse above Headwater Camp. This small stream averages about 4 in. in depth in July and the minimum flow even in the wet lower meadow is only about 0.5 cu. ft. per sec. Snow completely covers the headwater stream during winter and much of the spring.

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EVALUATION OF THE DAMS

Fourteen dams of three different types were constructed at suitable sites in the headwaters (Fig. 1). These were log dams, rock dams, and a dam of sticks and sod. Log dams consisted of two or three logs

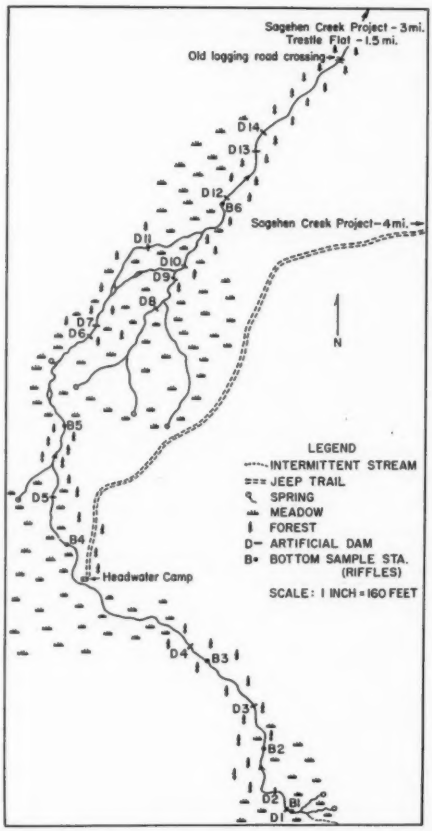

FIG. 1. Map of the headwater study area of Sagehen Creek.

laid one on top of the other with ends inserted 1 to 2 ft. into the banks. Small notches were cut in the top logs to act as spillways. Logs lying naturally across the creek were incorporated into two of the dams (D6, D7). Pyramid-type rock dams were constructed of boulders covered with smaller rocks and sod. An attempt was made to direct the outflowing water over a well-defined spillway. The dam of sticks and sod was similar to dams constructed by beavers. Logs were placed across the more exposed ponds to provide shelter. The dams, ranging from 10 to 27 in. in height and 5 to 15 ft. in width, backed up pools varying from 7 to 32 in. in depth. Other specifications of the dams and the pools behind them are listed in Table 1.

Rock dams were the easiest to construct, requiring an average of 3.6 man-hours per dam. Log and stick-and-sod dams required 4.5 and 6 man-hours per dam, respectively. All dams were built by untrained men and the use of trained crews would reduce construction times.

One year after installation, all eight log dams were operating perfectly, but by the third year, three log dams (D1, D6, D7) had been undercut and a fourth (D5) had been washed out. Better design might have eliminated washouts. Gee (1952) recommended that the top log be lower than the top of the stream bank to prevent dislodgement during high water and that logs be placed 6 ft. into each bank. The stick-and-sod dam remained intact over the 3-year period, but decaying sticks permitted the dam to settle about 6 in. and the water level to drop. Rock dams were not so successful as other types since two (D12, D14) were leaking badly after 1 year and all four were leaking in varying degrees after 3 years. Sod placed among the rocks to prevent leakage did not hold up well. Warner and Porter (1960) also found that rock dams were largely unsuccessful. Log dams required less maintenance than did rock dams, but a certain amount of maintenance was necessary to keep all types of dams operating successfully over extended periods.

PHYSICAL CHANGES RESULTING FROM DAMS

Several important physical changes were brought about by the construction of dams. A greatly reduced current in resulting ponds permitted an average deposition of 3.3 in. of silt, organic material, and gravel after 1 year and 4.8 in. after 3 years. While the ponds were filling with material washed in from above, holes were being created by the digging action of water passing over the dams. Even if some ponds become completely filled in, the dams will nevertheless serve the purpose of maintaining holes below them. An average water depth of 4.5

TABLE 1.—SPECIFICATIONS OF DAMS AND PONDS CONSTRUCTED IN UPPER SAGEHEN CREEK
(All dams were built in July 1957 except D9, which was built in August 1960)

DAMS				PONDS								
						Depth (in.)			Thickness of Silt (in.)		Bottom Type[1]	
Designation	Type	Height (in.)	Width (in.)	Length (in.)	Area (sq. ft.)	July 1957	Sept. 1958	Oct. 1960	Sept. 1958	Oct. 1960	Original	Oct. '60 (percent)
D1	log	10	112	215	124	14	12	5	2	6	G	90S, 10G
D2	log	18	125	330	206	23	17	9	6	9	—	100S
D3	rock	20	65	165	62	12	12	7	0.5	1–7	G, R	90S, 10G
D4	log	18	134	180	121	13	13	8	0.5	1–7	—	95S, 5G
D5	log	17	60	240	88	32	16	4	16	0–12	R	70S, 30G
D6	log	16	100	300	173	16	13	15	3	0.5	—	90S, 10G
D7	log	17	75	420	254	15	13	7	2	0–4	—	50S, 50G
D8	stick	19	73	186	81	17	16	9	1	3–14	G, R	90S, 10G
D9	log	18	78	350	131	—	—	17	—	0.5	R, B	90S, 10B
D10	log	14	65	570	234	17	15	15	2	2–8	—	100S
D11	log	16	101	650	433	15	13	4	2	5–9	G, B	95S, 5B
D12	rock	10	145	140	106	7	6	5	0.5	0–6	—	60S, 30G, 10B
D13	rock	27	170	130	112	17	12	7	5	0–8	—	60S, 20G, 20B
D14	rock	19	180	160	161	13	11	6	2	0–8	R, B	50S, 30R, 20B

[1] G, gravel; R, rubble; B, boulders; S, silt.

in. at six stream sites in July 1957 increased to 17.2 in. after damming, but had fallen to 5.8 in. by the fall of 1960. The low average depth in 1960 was due to silting and to 2 years of drought which rendered the stream nearly dry in some sections. In September 1957 the average width of 45 randomly selected stream stations was 3.6 ft.; the average width of 13 pond stations was 9.0 ft. This increase in width was accompanied by an increase in surface area of aquatic habitat; the 13 original stream sites contained 1,075 sq. ft. of surface, which was increased to 2,155 sq. ft. after damming. Ponds accounted for 13.2 percent of the surface area of the entire headwaters.

Damming may have increased water storage of the headwaters by raising the water table in adjacent meadows. However, the dams themselves did not store an appreciable amount of water since they were small and not designed to permit fluctuations of water levels.

Water temperatures below ponded sections in many streams have been found to be warmer than those above ponds in summer, but no temperature increase was detected below the headwater ponds on Sagehen Creek. Entering cold springs may have obscured warming effects of the headwater ponds. It is unlikely that trout lower in the drainage have been adversely affected since water temperatures in this region are generally well below those that are harmful to trout.

SURVIVAL AND SPAWNING OF BROOK TROUT

In July 1957, 128 wild brook trout, totaling 6.3 lb. in weight and averaging 126 mm. in total length, were introduced into the headwaters. These trout were obtained from Trestle Flat, a section of Sagehen Creek located 1.5 mi. downstream from the headwaters and near the natural upper limit of brook trout distribution. Trout over 150 mm. in length were tagged with Monel-metal jaw tags while smaller trout were marked by removing adipose fins.

During the following three summers, the numbers of the introduced trout remaining in the headwaters were determined with the use of a direct current electric shocker. Forty-nine trout were collected the second summer giving a 1-year survival rate of 38 percent. Seventy-three percent of the fish surviving to the second summer were collected the third summer and 39 percent of those surviving to the third summer lived to the fourth summer. These rates should be considered as minimal since some trout may have evaded the shocker and a few may have migrated downstream and out of the

study area. No trout from the headwaters were recorded during creel census or fish sampling operations downstream and losses due to migration were probably small. The relatively low survival to the second summer was not unexpected since the trout had to become conditioned to their new habitat and the winter of 1957–58 was extremely severe. Eleven ft. of snow covered the Sagehen Creek Project that winter and even deeper snows covered the headwaters. A relatively high volume flow in the creek during the fall of 1958 followed by a mild winter was associated with excellent survival to the third summer. An intermittent stream in the fall of 1959 was followed by a lower survival to the fourth summer. No fishing was known to have occurred in the headwaters during the study and all mortality is attributed to natural causes.

The study period was marked by extremes in weather; the first winter was one of the wettest in recent years and the second and third winters were two of the driest on record. Nevertheless, survival rates in the headwaters of Sagehen Creek were fairly high when compared to rates for other areas. In two Michigan streams survival rates of wild brook trout averaging about 195 mm. in length were found to be 37 and 59 percent over a 6-month fall and winter period (Adelman and Bingham, 1955). Needham, *et al.* (1945) found the 4-year average survival of wild brown trout over 100 mm. in length to be 20 percent during an 8-month fall and winter period in a California stream. Survival rates in the present study were for 12-month periods.

The introduced trout spawned successfully. Two fry were noted 1 year after stocking while eight yearlings and dozens of fry were collected or observed the second summer. Ninety-seven yearlings and 2-year-olds as well as numerous fry were collected the third summer. By 1960 a natural population was well established in the headwaters.

Trout were stocked at a density of 343 (17 lb.) per acre in the headwaters in 1957. This was low compared to the density of 3,244 trout (42 lb.) per acre present at Trestle Flat that year. Undoubtedly low trout density in the headwaters in association with the new ponds resulted in the excellent survival of introduced trout and their offspring.

BOTTOM FAUNA

A single square-foot sample of the bottom fauna was obtained at each of 12 gravel or rubble headwater riffle stations in July 1957 with a Surber sampler. Six of these riffles (B1–B6 in Fig. 1) were sampled in the same manner during the following two summers. After the 1957 sampling, dams were constructed so that the remaining six riffle stations (D1, 3, 5, 8, 11, 14) were included in the resulting ponds. A single ¼-sq.-ft. Ekman dredge haul was obtained at each of these six new pond stations during the summers of 1958 and 1959. Thirty rubble or gravel riffles, located 3 mi. downstream from the headwaters at the Sagehen Creek Project, were sampled each summer with a Surber sampler. The organisms from each sample were sorted, dried against blotting paper for 1 min., and weighed with a torsion balance.

Over 40 different types (mostly genera) of bottom organisms were identified from the headwater samples. Most important organisms in the riffles were mayfly nymphs, especially *Cinygmula*, and stonefly nymphs, particularly *Alloperla* and *Nemoura*. Large, limnephilid caddisfly larvae (*Neophylax*) were also numerous in the stream. Dominant organisms in the ponds were several genera of midge larvae, oligochaetes, the clam *Pisidium*, and a limnephilid caddisfly larva different from the common stream form.

Average standing crops of organisms at headwater and Sagehen Creek Project sites are given in Table 2. Weights of clams have been eliminated from total weights for pond samples since clams are not potential trout food in this creek. Average weights of bottom organisms per unit area at the pond sites in 1958 and in 1959 were 5 and 8 times heavier than the average weight per unit area at the same sites before ponding in 1957. Also, average weights of organisms

TABLE 2.—SUMMER STANDING CROPS OF BOTTOM ORGANISMS AT THE HEADWATER AND SAGEHEN CREEK PROJECT SITES (The stations altered by damming were riffles in 1957 but were ponds in 1958 and 1959)

Area	Sampling Dates	Permanent Riffle Stations		Stations Altered By Damming	
		Number of Samples	Avg. Number of Grams per Sq. Ft.	Number of Samples	Avg. Number of Grams per Sq. Ft.
Headwater	July 22–23, 1957	6	0.24	6	0.67
	Sept. 2–3, 1958	6	0.65	6	5.12
	July 17–22, 1959	6	0.39	6	3.48
	All years combined	18	0.43	12[1]	4.30[1]
Sagehen Creek Project	June 3–26, 1957	30	0.73		
	July 28–30, 1958	30	0.56		
	July 8–14, 1959	30	0.80		
	All years combined	90	0.70		

[1] 1958 and 1959 only.

in the ponds were much heavier than those at permanent riffle stations both in the headwaters and at the Sagehen Project. However, average weights from headwater riffles were not as heavy as those from riffles at the Sagehen Project. All differences between average weights discussed above exist whether the years are considered separately or collectively and all are significant at the 5 percent level according to the t test (Dixon and Massey, 1957, p. 121).

Although headwater riffles had a lower standing crop of bottom organisms per unit area than did Sagehen Project riffles, headwater ponds had a much greater standing crop than did these downstream riffles. It is concluded that the entire headwater area had at least as great a standing crop of bottom organisms as did a comparable area at the Sagehen Project.

GROWTH OF BROOK TROUT

In July 1959 total lengths and conditions of trout collected from the headwaters were compared with those from Trestle Flat. Trout were separated into age groups on the basis of scale studies. No attempt was made to separate sexes since the trout were not in breeding condition. The condition factor $K\,(TL)$ was calculated with the following formula:

$$K\,(TL) = \frac{\text{Weight in g.} \times 10^5}{\text{Length in mm.}^3}$$

Total length, rather than the more common standard length, was used since the trout were handled alive.

Average total lengths and condition factors of trout in age groups II, III, and IV are listed for the headwaters and Trestle Flat in Table 3. There are no significant differences between mean lengths of similar-aged trout from the two areas, but mean $K\,(TL)$ values of all age groups of headwater trout are significantly higher than those for Trestle Flat trout (5 percent level). The better condition of headwater trout is illustrated by Fig. 2.

TABLE 3.—AVERAGE LENGTHS AND CONDITION FACTORS OF TROUT COLLECTED FROM THE HEADWATER AND TRESTLE FLAT AREAS OF SAGEHEN CREEK IN JULY 1959

Area	Age Groups	Number in Sample	Avg. Total Length (millimeters)	Condition Factor (average)	Condition Factor (range)
Headwater	II	5	153.6	1.115	0.894–1.294
	III	23	183.1	1.143	0.983–1.325
	IV	4	203.5	1.187	1.099–1.278
	All	32		1.144	0.894–1.278
Trestle Flat	II	59	145.3	0.925	0.806–1.082
	III	11	190.3	0.960	0.591–1.157
	IV	1	196.0	0.890	
	All	71		0.931	0.591–1.157

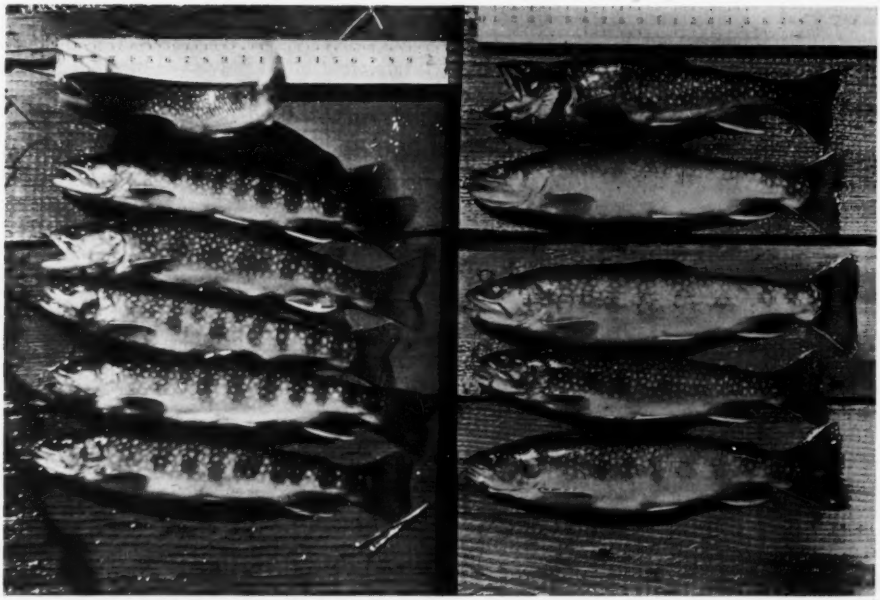

FIG. 2. Brook trout from Trestle Flat (left) and the headwaters (right) of Sagehen Creek. Trout about 200 mm. in length were selected as representatives of each group.

It is known that brook trout grow faster in warmer than in colder waters (Hazzard, 1932; Purkett, 1951) and that untagged trout grow faster than tagged trout (Smith, 1957; Seegrist, 1959). Water temperatures at Headwater Camp were considerably colder than those at Trestle Flat in July (Table 4). Many headwater trout bore jaw tags but no Trestle Flat trout bore tags. Despite relatively low temperatures in the headwaters and the presence of tags on headwater trout, these fish were of similar length and in better condition than were trout from Trestle Flat. Low trout density and adequate food in the headwaters resulted in the excellent condition of trout in this area.

DISCUSSION AND CONCLUSION

At the inception of this study, the headwaters were considered to be barren of trout since no resident fish were noted by direct observation, fishing, or in subsequent censuses. Anglers report catching trout in the headwaters many years ago and no physical barrier was apparent that could prevent trout from migrating to this area today. Why were the original trout and any recent migrants unable to survive in the headwaters? I believe that volume flow has gradually decreased during the past decade to the extent that no natural deep holes remained in which trout could survive severe winters and dry falls.

Several factors have been operating that could have caused a reduction in volume

TABLE 4.—WATER TEMPERATURES AT HEADWATER CAMP AND TRESTLE FLAT STATIONS OF SAGEHEN CREEK

Date	Headwater Camp		Trestle Flat	
	°F.	Std. Time	°F.	Std. Time
July 21,1959	57	1145	62	1100
	62	1530	70	1530
July 22, 1959	53	1045	62	1045
	58	1530	69	1530
	54	1800	67	1900

flow in the headwaters. In recent years, winters have been generally drier than they once were. After logging operations in part of the upper watershed, a brush field has developed and has increased the transpiration rate. Also, the headwater meadows have been heavily grazed and trampled by domestic sheep with the result that soils have been compacted and eroded and the water-holding capacity lessened.

The artificial ponds are similar to beaver ponds on Sagehen Creek since they provide greater amounts of aquatic habitat, shelter, bottom organisms, and trout than would otherwise be present (Gard, 1961). In areas where beaver foods are scarce, artificial dams will provide a habitat comparable to that created by beaver dams.

On the basis of a 4-year study, it is concluded that brook trout survived, grew rapidly, and reproduced in the headwaters of Sagehen Creek after the stream was deepened and widened in various places by damming. Construction of artificial dams in other small headwater streams in the Sierra Nevada, accompanied by the introduction of wild brook trout, is suggested as a feasible means of establishing trout populations and providing trout fishing where these do not exist at present.

SUMMARY

Small dams were constructed in the headwaters of Sagehen Creek, California, in an attempt to create a habitat suitable for brook trout. The study was initiated in July 1957 and terminated in January 1961. Following erection of the dams, 128 brook trout from a population lower in the creek were introduced. Survival rates of the trout were high, averaging 50 percent for the three study years. Spawning was successful and a population of resident trout was well established by 1960. Headwater trout were in better condition than trout from lower elevations despite lower temperatures in the headwaters.

Introduced trout were successful in the headwaters because ponds provided necessary living space and shelter, and initial trout density was low. Construction of small dams accompanied by introduction of wild brook trout into headwaters of other Sierra Nevada streams is suggested as a means of establishing trout populations and trout fishing.

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THE RELATION OF FEEDING BEFORE STOCKING TO CATCHABILITY OF TROUT[1]

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Many sportsmen have been concerned about fishermen following the stocking truck. One method of discouraging this practice would be to minimize the advantage of fishing immediately after stocking. Since there is generally an inverse relationship between the proportion of stocked fish that are creeled and the length of time they have been in the stream, any procedure that discourages stocked fish from biting should have a temporary effect of probably not over 1 or 2 days.

Under standard Pennsylvania practice, trout are not fed for several days before transportation to stocking points. This results in a lowered metabolic rate so that more fish can be hauled in each transportation unit. Lietritz suggests that trout, when reared on meat and fish products, should not be fed for at least 48 hr. before transportation. (Lietritz, Earl. 1959. Trout and Salmon Culture. Fish Bull. No. 107. Calif. Dept. Fish and Game.) An unpublished report from New Jersey (personal communication from H. Underhill, Trenton, New Jersey) suggested that trout fed pellets before shipping could be handled as well as starved fish.

It was hypothesized that feeding pellets prior to stocking would eliminate or reduce the ravenous appetite typical of starved trout. They would thus be less subject to being caught immediately after stocking. An experiment was designed to determine the effect of feeding, prior to and including the day of loading fish for stocking, on the catch of trout for 3 successive days. The experiment was designed also to provide basic information on the sources and nature of variation in fishing experiments.

Procedure

Two similar experiments were conducted at the Benner Spring Fish Research Station, Bellefonte, Pennsylvania. The first experiment was conducted April 22–24, 1958, and the second May 19–21, 1958. The two experiments were conducted in separate spring-fed raceways approximately 700 ft. long. In both experiments the raceway was divided into three sections separated by screens. Nine regularly spaced fishing stations were established on each section, although no barriers to fish movement were erected within sections.

In each experiment, nine anglers fished the first section of the raceway the first day, the second section the second day, and the third section the third day. It was not possible to use the same nine fishermen throughout the two experiments.

Each day three of the nine fishermen used spinners as lures; three used artificial nymphs; and three used worms. Insofar as possible, each fisherman was given the choice of lure to use. Throughout this paper the term baits includes all three kinds of lures.

Because trout tended to migrate to the ends of a restricted raceway, a system of rotating the fishermen was devised to minimize the possibility of bias in favor of or against any particular kind of lure. Each fishing day was divided into nine 10-min. periods. Each fisherman fished 10 min. at each station. A systematic rotation arrangement was such that during any fishing period the nine linearly placed fishermen could be divided into three groups, each

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of which contained a spinner-, nymph-, and worm-fisherman.

Three hundred each of 7- to 11-in. brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and rainbow trout (*Salmo gairdneri*) were selected at random for each experiment. In the first experiment all trout were fed pellets until 3 days before stocking. The pellet feeding was continued with half of each species until 2 hr. before loading on the transportation unit. Trout treated in this manner are referred to as fed trout. The second group was starved for the last 3 days. A loss in one of the brook-trout ponds necessitated reducing the number in each group of brook trout to 129. The trout in each group were fin-clipped for identification.

To simulate normal stocking operations, the trout were placed in a transportation unit and hauled around for 1 hr. before they were placed in the experimental area. No trout were lost during this transportation. One-third of the starved and one-third of the fed trout of each species were placed in each of the three sections of the raceway.

The second experiment differed from the first in two respects: Fifty starved and 50 fed fish of each species were available for each of the 3 sections; and the starved trout were without feed for only 2 days rather than 3 days.

The water was clear during both experiments and the fish could see the anglers. Placement of stone deflectors in the raceways or planks across the raceway tended to reduce fish movement but did not provide equal concentrations of trout at all stations. The three periods 0–1.5, 24–25.5, and 48–49.5 hours after stocking are referred to as the first, second, and third days, respectively.

Relation of Catch to Feeding History and Bait

A record of the fish caught at each station by each fisherman during each fishing period was obtained. Review of these data made it apparent that there was no point in preserving the identity of results for individual stations within sections. The data from the first experiment were therefore summarized in terms of starved and fed fish of each species caught by each fisherman during each 90-min. period. A complete analysis of variance was made for the data. This included separate analyses for each species for each day, analyses for each species for days combined, analyses for each day for species combined, and the analysis for days and species combined. Space limitations prohibit inclusion of these detailed results, but they may be obtained directly from the senior author.

Variability Among Fishermen

One obvious feature of the data was the extreme variability among fishermen within baits. All fishermen participating in this experiment were presumed to have a fair degree of skill in the use of the bait selected. Nevertheless gross differences in skill or luck resulted in extremes of catch such as the comparisons in Table 1.

The consequence of this kind of variability in the conduct of a fishing experiment is that only extremely wide differences between treatments can be ascertained with any degree of assurance; i.e., the probability of a Type II error is very high.

The coefficients of variability from the analyses of variance of data tabulated for individual fishermen in experiment No. 1 are given in Table 2. With such a high residual error in each analysis none of the sources of variation (baits, feeding, and the

Table 1.—Examples of Variation in Number of Fish Caught by Fishermen

Fishermen	Day	Number of Fish Caught
Spinner No. 1	1	16
Spinner No. 2	1	5
Spinner No. 3	2	27
Spinner No. 4	2	1
Nymph No. 5	1	26
Nymph No. 6	1	1
Nymph No. 7	2	1
Nymph No. 8	2	28
Worm No. 9	1	20
Worm No. 10	1	2
Worm No. 11	3	5
Worm No. 12	3	22

TABLE 2.—COEFFICIENTS OF VARIABILITY (PERCENT) FROM ANALYSES OF VARIANCE OF DATA TABULATED FOR INDIVIDUAL FISHERMEN EACH DAY IN EXPERIMENT 1[1]

Species	First Day	Second Day	Third Day	Days Combined
Brook trout	132	78	33	80
Brown trout	115	105	99	107
Rainbow trout	154	76	147	130
Species combined	140	90	76	100

[1] The residual error with which the coefficient of variability was determined in each analysis was as follows:
For each species each day—Variation among fishermen within feeding × baits.
For each species for days combined—Variation among fishermen within feeding × baits within days.
For each day for species combined—Variation among fishermen within feeding × baits within species.
For days and species combined—Variation among fishermen within feeding × baits within species within days.

baits × feeding interaction) was significant for individual analyses for one species for one day.

When data for species were combined, only the effect of feeding on the first day was significant. When data for days were combined for each species, none of the sources of variation was significant. When data for days and species were combined, only the mean squares for species and for feeding were statistically significant.

BAITS

The average number of fish caught per fisherman per day for the three baits were:

Spinners	11.33
Nymphs	12.00
Worms	11.33

The effect of baits *per se* is confounded with the skill of the groups using the different baits. To the extent that there were differences in fishing skill among the groups, any differences among baits would have been invalidated. There are many inherent difficulties in devising an experiment to measure the relative effectiveness of kinds of baits for catching fish. Maneuvers such as having all fishermen use all baits offer no solution to the problem. Confirmed worm-fishermen may be completely inept in the use of flies, whereas fly-fishermen may be fairly skillful with worms, but less skillful than with flies.

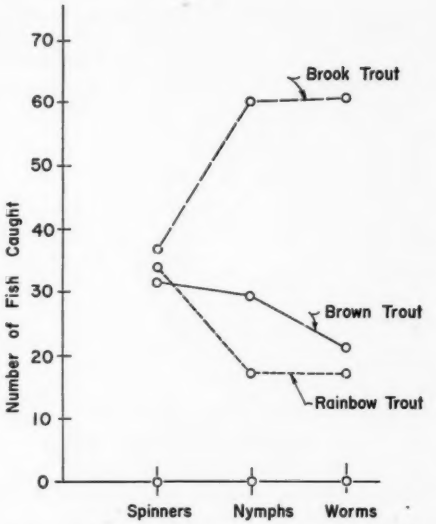

FIG. 1. The species × baits interaction. Totals for three fishermen each day for 3 days including both starved and fed trout. Data from Experiment 1.

INTERACTIONS INVOLVING BAITS

The analysis of variance results did not justify drawing specific conclusions about interactions involving baits. The data, however, indicate trends that warrant consideration.

Species × Baits

The three species of trout did not respond similarly to all baits (Fig. 1). All species were equally prone to being caught with spinners. Brook trout were caught more frequently on nymphs and worms (natural-appearing baits) than on spinners (attractor baits). The opposite was true of rainbow trout. Brown trout responded less to worms than to nymphs and spinners, which were equally attractive.

Feeding × Baits

Starved and fed fish responded differentially to natural and artificial baits. The

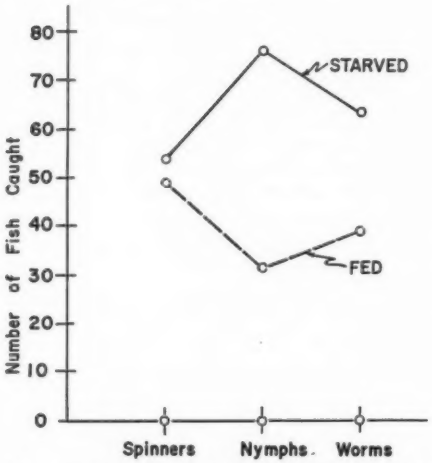

FIG. 2. The feeding × baits interaction. Totals for three fishermen each day for 3 days and three species. Data from Experiment 1.

starved fish showed a preference for natural baits, nymphs and worms, whereas fed fish were relatively more susceptible to spinners (Fig. 2).

Feeding × Baits × Days

If the hypothesis that starved and fed fish do respond differentially to natural and artificial baits is correct, there should have been a greater difference in preference for baits between starved and fed fish on the first day than on the second or third day. This would be logical, because by the third day, either all fish should have started consuming natural feed in the raceway and hence behaving as fed fish, or if feeding was very restricted, all fish would have become starved and would behave accordingly.

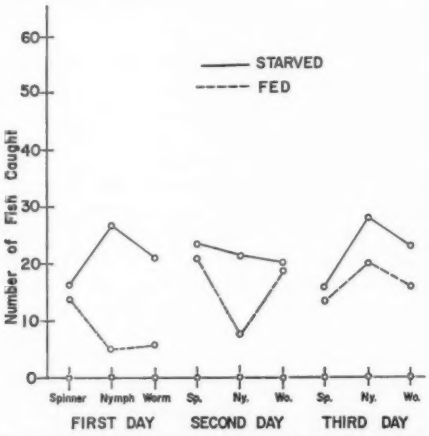

FIG. 3. The feeding × baits × days interaction. Totals for three fishermen for three species. Data from Experiment 1.

The results illustrated in Fig. 3 suggest that feeding was restricted and all fish tended to behave as starved fish by the third day. The number of starved fish caught was fairly constant for the 3 days (62, 65, and 65), whereas the number of fed fish caught increased from 25 on the first day to 48 and 47 on the second and third days. Bait preference of starved and fed fish was quite different on the first day, less so on the second, and quite similar by the third day.

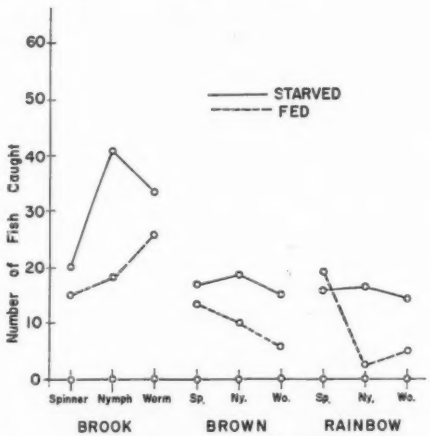

FIG. 4. The species × baits × feeding interaction. Totals for three fishermen for 3 days. Data from Experiment 1.

Species × Baits × Feeding

The indications of an interaction between species, baits, and feeding appear in Fig. 4. A preference for natural-appearing baits by both fed and starved brook trout is shown.

TABLE 3.—PERCENTAGE OF AVAILABLE TROUT CAUGHT ON SUCCESSIVE DAYS FOLLOWING STOCKING (Totals for nine fishermen each day—three fishermen for each of three baits. All figures rounded to nearest whole percent)

Species	Day	Experiment 1		Experiment 2		Experiments Combined	
		Starved	Fed	Starved	Fed	Starved	Fed
Brook trout	1	72	23	50	24	61	24
	2	70	58	71	64	70	61
	3	79	63	64	60	72	62
	Avg.	74	48	62	49	68	49
Brown trout	1	34	12	38	14	36	13
	2	40	26	24	14	32	20
	3	28	24	26	24	27	24
	Avg.	34	21	29	17	32	19
Rainbow trout	1	28	18	16	8	22	13
	2	30	20	14	13	22	16
	3	34	16	38	34	36	25
	Avg.	31	18	23	18	27	18
Species combined	1	45	18	35	15	40	16
	2	47	35	36	30	42	32
	3	47	34	43	39	45	37
	Avg.	46	29	38	28	42	29

Fed rainbow trout manifested a definite preference for spinners, whereas starved rainbow trout were taken with equal frequency with all three baits. Under the same circumstances there was little difference between fed and starved brown trout with respect to their preference for the three baits.

RESULTS EXPRESSED AS PERCENTAGES

To overcome the difficulties resulting from variability in skill among fishermen and the confounding of group skill with bait effect, the data for both experiments were summarized as the pooled results for fishermen and baits combined. The data have been expressed as percentages of available trout caught on successive days (Table 3).

In the analysis of the data, the two experiments were handled as two replications. The error term used in the analysis of variance (Table 4) included all the interactions involving experiments (days × experiments, species × experiments, feeding × experiments, species × days × experiments, species × feeding × experiments, feeding × days × experiments, and species × feeding × days × experiments).

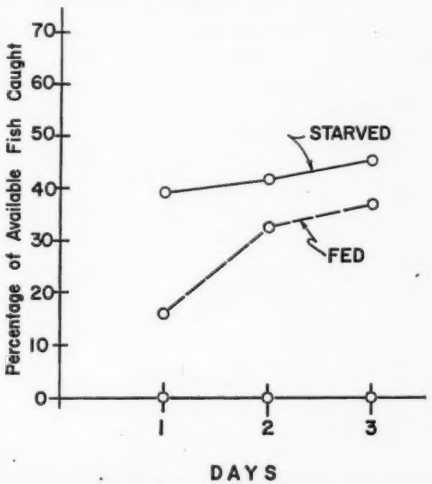

FIG. 5. The feeding × days interaction. Data from Experiments 1 and 2 combined.

TABLE 4.—ANALYSIS OF VARIANCE OF THE DATA IN TABLE 3 ON PERCENTAGE OF AVAILABLE FISH CAUGHT

Source of Variation	D.F.	Untransformed Data		Arcsin Transformation	
		Mean Square	F	Mean Square	F
Experiments	1	171.18	3.37	92.44	4.26
Days	2	511.18	10.08[2]	220.09	10.15[2]
Species	2	4,739.06	93.51[1]	1,776.00	81.92[1]
Feeding	1	1,620.07	31.96[1]	676.00	31.18[1]
Species × days	4	222.48	4.38[3]	78.33	3.61[3]
Species × feeding	2	83.68	1.65	21.34	0.98
Feeding × days	2	213.14	4.20[3]	100.08	4.62[3]
Species × feeding × days	4	73.80	1.45	22.42	1.03
Residual error	17	50.68	—	21.68	—
Total	35	—			
Coefficient of variation (%)		20.17	—	12.97	—

[1] $P < 0.001$; [2] $P < 0.01$; [3] $P < 0.05$.

EFFECT OF FEEDING

Prior feeding reduced the catchability of trout. As an average of all species, days, and experiments, the comparative values for fed vs. starved trout caught were 29 and 42 percent. In every valid comparison in Table 3 the percentage of starved trout caught exceeds the percentage of fed trout caught.

Prior feeding was equally effective in reducing catchability for all three species. This is indicated by the non-significant first order interaction, species × feeding. The similarity of the response of different species to feeding before stocking is expressed most dramatically in Table 5. The data in Table 5 were obtained by converting the data in Table 3 so as to express the starved and fed fish caught as the proportion of the

TABLE 5.—STARVED AND FED FISH CAUGHT EXPRESSED AS THE PERCENTAGE OF THE TOTAL NUMBER OF FISH CAUGHT (Starved + fed = 100%)

(Totals for nine fishermen—three fishermen for each of three baits)

Species	Day	Experiment 1		Experiment 2		Experiments Combined	
		Starved	Fed	Starved	Fed	Starved	Fed
Brook trout	1	76	24	68	32	72	28
	2	55	45	53	47	54	46
	3	56	44	52	48	54	46
	Avg.	62	38	58	42	60	40
Brown trout	1	74	26	73	27	74	26
	2	61	39	63	37	62	38
	3	54	46	52	48	53	47
	Avg.	63	37	63	37	63	37
Rainbow trout	1	61	39	67	33	64	36
	2	60	40	52	48	56	44
	3	68	32	53	47	61	39
	Avg.	63	37	57	43	60	40
Three species combined	1	70	30	69	31	70	30
	2	59	41	56	44	58	42
	3	59	41	52	48	56	44
	Avg.	63	37	59	41	61	39

FIG. 6. View of 230 feet of one raceway in experimental area. Planks gave cover to trout and aided in dispersion of the fish.

total number caught. Thus the percent starved caught plus the percent fed caught always equals 100. The relation between Table 3 and Table 5 is demonstrated in Table 6, with the data from the first day for the two experiments combined.

When all three days of fishing are considered, the ratio of starved to fed fish caught for all three species is almost exactly 3:2 (Tables 3 and 5).

One of the specified requirements for a satisfactory procedure to reduce catchability of trout immediately after stocking was that its effect should be of short duration.

TABLE 6.—RELATIONSHIP OF DATA IN TABLES 3 AND 5

Species	Percentage of Available Trout Caught		Percentage of Total No. of Fish Caught	
	Starved	Fed	Starved	Fed
Brook trout	61	24	72	28
Brown trout	36	13	74	26
Rainbow trout	22	13	64	36
Species combined	40	16	70	30

The significant ($P < .05$) interaction, feeding × days, indicates this requirement was satisfied. The difference between starved and fed trout diminishes with time (Fig. 5). As suggested earlier, this was probably due to the fact that feeding in the raceway was very restricted, so that fed trout essentially became starved trout and behaved accordingly.

As an average of all species, the available fed trout caught increased from 16 percent on the first day to 37 percent on the third day. At the same time the percentage of starved trout caught increased only from 40 to 45 percent (Table 3). This suggests that increasing the starvation level of trout does not produce a corresponding level of catchability.

The procedure used in developing the data in Table 5 eliminates variation due to differences between experiments and among days and species. For example, any difference in the response of species to feeding observed in Table 5 is due to the feeding × species interaction.

The remarkable similarity of meaningful relationships in the two experiments leads to attaching a high degree of credence to the results.

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WHISTLING-COCK INDICES AND BOBWHITE POPULATIONS IN AUTUMN

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Several investigators (Bennitt, 1951; Reeves, 1954; Rosene, 1957) indicate that whistling-cock counts of bobwhites (*Colinus virginianus*) in summer foreshadow bobwhite populations during the subsequent autumn and winter. Counts of whistling cocks in summer are represented as a reasonably accurate advance index of quail populations subsequently available to the hunter. This index cannot take account of reproductive success or population losses during summer and autumn. Hence, it seems desirable to re-examine published data on the relationship of counts of whistling cocks to autumn populations and to evaluate previously unpublished observations.

Data

Bennitt's (1951:8–22) data for quail in Missouri cover the 10 years 1939 to 1948, inclusive, for each of eight "zoogeographic" regions. Counts of whistling cocks were made at stations "consisting of about 30 mi. of road" during the first hour after sunrise, July 13–28. Stops, usually of 2 or 3 min. duration, were made at 1-mi. intervals in order to count the number of birds calling. The "call index" is the average number of calling birds per stop. Call indices were corrected for the effect of temperature and were averaged for each major soil type. Soil-type call indices were prorated according to the area of each major soil type to obtain regional call indices. The regional call indices were in turn prorated according to the area of each region to obtain the state call index. Hunting success was determined for each region by dividing the total number of birds bagged by the number of gun hours. State hunting success was derived by prorating regional hunting success according to the area of each region.

Data extracted from Reeves (1954:25–26, Tables 5 and 7) for Indiana quail cover the 5 years 1947 to 1951, inclusive, for each of six districts. Calling quail were counted for 1 hr. from sunrise during the last week of June on each of 100 routes in 88 of 92 counties. The routes were mostly within one soil association, 9 mi. in length, and with 10 listening stops. Three to 5 min. were spent at each stop. A call index, the average number of quail calling per stop, was determined for each soil association; these indices were prorated by acreage to obtain a district index. Kill data were obtained from questionnaires mailed to a random sample of licensed hunters.

Rosene's (1957) data collected during the years 1950 to 1953, inclusive, were obtained from four study areas totaling 5,571 a. in Alabama and six study areas totaling 6,702 a. in South Carolina. Individual areas varied in size from 507 to 1,745 a. Listening posts and an outline of the estimated audible range from each were marked on aerial maps of each area. Calling quail were counted by marking their approximate locations on an aerial photograph during a stay of about 8 min. at each listening post. The surveys began about 25 min. after official sunrise and lasted about 1 hr. and 25 min. During the period June 20 to July 10 two successive mornings were spent on each area. The manner in which coveys were censused in the succeeding hunting seasons is not described.

Data on the number of whistling quail and the number of coveys in autumn (Table

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TABLE 1.—ANALYSIS OF BENNITT'S HUNTING SUCCESS DATA (y), WITH COVARIANCE ON CALL INDEX (x)

Category	d.f.	Sx^2	Sxy	Sy^2	d.f.	Adj. M.S.	Probability
Years	9	4.4851	2.1106	1.7996	9	0.1120	0.001–
Regions	7	8.4434	0.7342	0.8952	7	0.1268	0.001–
Error	63	7.8358	1.6021	1.7195	62	0.0224	
Error regression	—	—	—	—	1	0.3276	0.001–

4) on the Crab Orchard National Wildlife Refuge, Williamson County, Illinois, cover the 5 years 1948 to 1953, inclusive, excepting 1950, for nine plots, five in Area I (3,500 a.) and four in Area II (2,450 a.). These areas have been described by Hanson and Miller (1961). The nine plots ranged from 421 to 607 a. in area, only one being less than 500 a. Whistling-cock counts were made between June 15 and July 15 in the first 2 hr. after sunrise. Temperatures ranged from 60 to 80°F. The locations of whistling cocks were plotted on area maps by an observer who moved along lines through the centers of tiers of 40-a. tracts (legal divisions). Coveys were located and counted during intensive and repeated searches with bird dogs in October.

A whistling-cock count and the number of coveys present in November (Table 6) were available for 1946, 1947, and 1948, for two areas. [Area I, 1,600 a.; Area II, 600 a. in Davis County, Iowa, described by Klimstra (1950)]. Because the areas were hilly and virtually roadless, the call counts were made from 28 listening posts on Area I and 18 on Area II, located to provide complete coverage of the areas. Whistling-cock counts were made by mapping the locations of birds heard calling in the hour after sunrise, during a 2- to 5-min. stay at each listening post; an observer moved from post to post on successive days suitable for making counts, between June 23 and July 8, inclusive, until both areas had been surveyed. Coveys were censused in November by an observer intimately acquainted with the areas and the resident quail populations.

Unusually accurate data on the number of quail calling in early summer and number of coveys present in autumn (Table 8) were available for the years 1951 to 1958, inclusive, from a single 1,800-a. area near Carbondale, Jackson County, Illinois, described by Klimstra and Scott (1958). Whistling bobwhites were located on a map by an observer recording at systematically located listening posts between June 23 and July 14 for the 8 years 1951 to 1958. The number of coveys present was determined during late October and early November by experienced observers aided by bird dogs.

METHODS

Our general method was analysis of covariance of autumn numbers (hunting success, kill, or coveys), using number of whistling cocks or call index as the independent variable and separating the total variation into portions attributable to years, to "regions," and to "error." Thus "error" refers to the failure of differences between

TABLE 2.—ANALYSIS OF REEVES' KILL DATA (y), WITH COVARIANCE ON CALL INDEX (x)

Category	d.f.	Sx^2	Sxy	Sy^2	d.f.	Adj. M.S.	Probability
Years	4	1.5907	6.72	8,237	4	2,150	0.05–
Regions	5	5.7319	764.54	178,408	5	21,034	0.001–
Error	20	3.9783	90.53	13,020	19	577	
Error regression	—	—	—	—	1	2,060	0.1–

TABLE 3.—ANALYSIS OF ROSENE'S COVEY DATA (y), WITH COVARIANCE ON AVERAGE NUMBER CALLING (x)

Category	d.f.	Sx^2	Sxy	Sy^2	d.f.	Adj. M.S.
Years	2	9.52	3.22	13.58	2	
States	1	172.48	259.80	391.32	1	16.21
Areas (in states)	8	1,052.15	1,236.80	1,740.94	7	41.01
Years × States	2	174.01	108.64	73.55	(2	36.78)
Years × Areas	16	169.85	–4.75	386.58	(16	24.16)
Areas regression	—	—	—	—	1	1,453.86

years to be constant from region to region, or equally, the failure of differences between regions to be constant from year to year. The individual year and individual region regressions were tested for heterogeneity.

In addition, the ratio of autumn population to whistling cocks was analyzed for some sets of data to test whether the autumn population was directly proportional to the number of whistling cocks. By analyzing the ratio it was implicitly assumed that the error variance was proportional to the square of the autumn population, that is, that errors were proportional to true values.

RESULTS

Bennitt's (1951:23–24, 50) regression formula, $Yc = a + bX$ (where Yc = hunting success, X = call index, $a = 0.2064$, and $b = 0.9444$), appears to be in error, for we found $a = 0.9264$ and $b = 0.2142$. Thus, the values of a and b were transposed, and were probably slightly in error (but his Table 16 has at least one misprint: the average "% + or –" for "NRiverbreaks" should be –5.0, not –4.0).

The derivation of Bennitt's regional correction factors was not fully explained, and we could not deduce it from his text, formula, and tables. After trial of several procedures possibly used by Bennitt, we concluded that there were errors in his factors.

Our analysis (Table 1) of Bennitt's (1951: 23, Table 16) data found a significant ($P < 0.001$) relation of hunting success to call index, accounting for about 19 percent of the hunting success error sum of squares. Both regions and years proved to be significantly ($P < 0.001$) heterogeneous after adjustment to equal values of call index. That is, hunting success differences between regions, and between years, could not be fully explained on the basis of observed differences in call index.

Further examination of Bennitt's data showed that the year and region regressions were not significantly different from the

TABLE 4.—THE NUMBER OF WHISTLING BOBWITE QUAIL HEARD DURING LATE JUNE AND EARLY JULY, AND THE NUMBER OF COVEYS OF BOBWHITE QUAIL OBSERVED DURING THE LAST HALF OF OCTOBER ON THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Location	1948		1949		1951		1952		1953	
	Whistlers	Coveys	Whistlers	Coveys	Whistlers	Coveys	Whistlers	Coveys	Whistlers	Coveys
AREA I										
Plot 1	8	25	27	26	32	14	19	14	29	27
Plot 2	9	3	6	8	26	14	16	8	16	17
Plot 3	1	3	4	2	10	3	5	2	7	8
Plot 4	17	13	20	18	42	17	21	10	39	16
Plot 5	9	6	3	7	23	11	17	5	16	13
AREA II										
Plot 1	19	17	21	11	29	14	21	8	31	2
Plot 2	9	5	18	5	20	10	13	10	15	7
Plot 3	12	1	22	23	46	10	29	15	25	10
Plot 4	11	7	16	12	42	11	27	9	20	6
Total	95	80	137	112	270	104	168	81	198	106

TABLE 5.—ANALYSIS OF CRAB ORCHARD COVEY DATA (y), WITH COVARIANCE ON NUMBER WHISTLING (x)

Category	d.f.	Sx^2	Sxy	Sy^2	d.f.	Adj. M.S.	Probability
Years	4	1,937	197	100	4	87.5	0.1+
Areas	1	326	−117	42	1	272.0	0.05–
Plots (in areas)	7	1,912	1,133	950	6	46.3	
Years × Areas	4	65	107	209	3	11.0	
Years × Plots	28	835	−25	546	(28	19.5)	
Pooled Plots and Years × Areas regression	—	—	—	—	1	778	0.001+
Plots regression vs. Years × Areas regression	—	—	—	—	1	70	
Pooled Plots and Years × Areas deviations	—	—	—	—	9	34.6	

error regression. Hence, a forecast for an individual region is given by

$$y_R = \bar{y}_R + b(x_R - \bar{x}_R),$$

where

$\bar{y}_R$ is the regional observed mean hunting success for the 10 years,
$\bar{x}_R$ is the regional observed mean call index for the 10 years,
b is the error regression coefficient, 0.2045,
x_R is the newly observed regional call index.

The mean square error of such forecasts is

$$V_R = s^2 \left[1 + \frac{1}{n_y} + \frac{(x - \bar{x}_R)^2}{Sx^2} \right] + s^2_y,$$

where

s^2 is the mean square deviation from the error regression, 0.0224,
n_y is the number of years (10) in the data,
Sx^2 is the error sum of squares for call index, 7.8358,
s^2_y is the year component of variance, $(0.1120–0.0224)/8 = 0.0112$.

Because the error regression accounts for only about 19 percent of the error sum of squares, and because the year component of variance is relatively large, such forecasts will be of limited precision. In fact, the forecasting error will be about 0.193, or 13.6 percent. The average departure ignoring sign should be almost 0.8 of this, or about 10.9 percent, a figure which coincidentally agrees closely with Bennitt's value of 11.2 percent. However, the improvement from 0.221 to 0.193 is so small that the work of counting whistling cocks cannot be considered worthwhile.

A similar forecast for the whole state is given by

$$\hat{Y} = \bar{y} + b(x - \bar{x}),$$

where

$\bar{y}$ is the state observed mean hunting success for the 10 years of data,
$\bar{x}$ is the state observed mean call index for the 10 years of data, and
x is the newly observed state call index.

The variance is given by

$$V = s^2 \left[\frac{1}{n_R} + \frac{1}{n} + \frac{(x - \bar{x})^2}{Sx^2} \right] + s^2_y,$$

where

n_R is the number of regions, 8, and
n is the number of data, 80.

The forecasting error will be about 0.121 (about 8.1 percent) reduced from 0.159.

Another possible method is to forecast on the basis of the previous year's hunting success, but there is no advantage except avoiding the work of counting whistling cocks, nor does an advantage result from using both the number of whistling cocks and the previous year's hunting success.

The error variation was further explored for heterogeneity among years and among regions. Years proved significantly heterogeneous ($P < 0.05$), suggesting that spatial forecasts (that is, extrapolations to additional regions) should be based upon different regression coefficients in different years. No such heterogeneity appeared in the regional regression.

Our analysis (Table 2) of Reeves' (1954:

TABLE 6.—THE CALL INDEX OF WHISTLING BOBWHITE QUAIL HEARD IN LATE JUNE AND EARLY JULY, AND THE NUMBER OF COVEYS OF BOBWHITE QUAIL OBSERVED IN FALL, ON AREAS NEAR ELDON, DAVIS COUNTY, IOWA

Location	1946		1947		1948	
	Whistlers	Coveys	Whistlers	Coveys	Whistlers	Coveys
Area I	1.64	9	1.82	10	1.28	3
Area II	1.72	4	0.94	6	1.22	1
Total	—	13	—	16	—	4

25–26, Tables 5 and 7) data found results similar to those for Bennitt's data, except that the error regression coefficient is of doubtful significance. The forecasting error is about 31,400 birds, or about 26 percent for an average region.

Our analysis (Table 3) of Rosene's (1957) data found no significant regression of fall coveys on number of whistling cocks in the interaction of years with areas within states. Furthermore, there was no significant difference between years, between states, or in the interaction of years and states, when adjusted to equal numbers of whistling cocks by means of the areas-within-states regression. However, there was a significant regression ($P < 0.001$) for areas within states. Thus, Rosene's (1957) data give no indication of any temporal relation, only a spatial one. That is, the data indicate that there is a (significant) regression appropriate to estimating the number of coveys on an additional area in the same year only.

Rosene used the spatial regression to make temporal forecasts, and gives a table (1957:Table 3) for forecasts for the total of 10 areas which appears to indicate that the forecasting formula was very successful. This appearance probably results from the fact that the observed changes in both whistling cocks and number of coveys were very small and provided no adequate basis for a test.

The analysis (Table 5) of the Crab Orchard data reveals no significant regression in the interaction of years with plots within areas. However, the regression in the interaction of years with areas is significant ($P < 0.01$), offering a basis for a temporal forecast of the number of coveys in fall for whole areas, though not for plots within areas. These areas were relatively large, requiring a large outlay of effort to determine the number of calling quail, and relatively similar in environment. Also, there is a significant regression for plots within areas (analogous to that for areas within states as in Rosene's (1957) data).

The Eldon, Iowa, data are so few in number that there was no prospect of significant regressions or effects of years or areas (Table 7). The Carbondale data refer to a single area, and the regression (Table 9) of coveys on number of whistling cocks is of doubtful significance ($P < 0.1$).

As mentioned under "Methods," the ratio of autumn population to number of whistling cocks was analyzed for some sets of data. For Bennitt's data, there was a highly significant difference between regions, which shows that a simple proportionality is inadequate to represent autumn population as a function of number of whistling cocks. This finding was substantiated in the Reeves data, and years proved significant in the Crab Orchard data. Hence, proportionality can be confidently discarded.

DISCUSSION

In attempts to solve the problem of forecasting autumn quail populations, a clear distinction must be made between formulas for forecasts in space and forecasts in time. A regression formula derived from data for a single year and relating autumn popula-

TABLE 7.—ANALYSIS OF ELDON, IOWA, COVEY DATA (y), WITH COVARIANCE ON NUMBER WHISTLING (x)

Category	d.f.	Sx^2	Sxy	Sy^2
Years	2	0.1945	1.51	39.0
Areas	1	0.1233	1.58	20.3
Error	2	0.2689	0.04	2.3

TABLE 8.—THE CALL INDEX OF BOBWHITE QUAIL HEARD IN LATE JUNE AND EARLY JULY, AND THE NUMBER OF COVEYS OF BOBWHITE QUAIL OBSERVED IN FALL, ON AN AREA NEAR CARBONDALE, JACKSON COUNTY, ILLINOIS

Year	Call Index	Coveys	Ratio of Coveys to Call Index
1951	1.81	13	7.2
1952	1.53	13	8.5
1953	2.71	20	7.4
1954	1.97	27	13.7
1955	2.08	24	11.5
1956	2.09	27	12.9
1957	1.61	42	26.1
1958	5.76	46	8.0
Total	—	212	—

tion to numbers of whistling cocks in summer is appropriate to the problem of "forecasting" the autumn population in additional areas in the same year, but it has no logical relation to the problem of forecasting the populations in a new year by the use of the numbers of whistling cocks in the new summer. If such a regression is observed within each of several years, and if these regressions are homogeneous, a basis is established for expecting the within-year regression to be the same in a new year. This would permit "forecasting" which areas will be *relatively* populous in the new autumn, and would be useful for directing hunters to the areas in which hunting will be best. However, such a regression is not acceptable or suitable for the prime management problems of setting the length of the open season or establishing bag limits.

In the several sets of data we examined, there was little indication that year-to-year changes in numbers of whistling cocks in summer was predictive of autumn populations, and hence only a relatively small portion of the variance could be explained.

TABLE 9.—ANALYSIS OF VARIANCE OF CARBONDALE FALL COVEYS

Category	d.f.	Mean Square	Probability
Regression on call index	1	378	0.1+
Deviations	6	109	

In an effort to estimate fall quail populations in Iowa, Kozicky, *et al.* (1956) concluded: "It should be remembered that at present the whistle and brood counts serve only as indices of potential quail production. The October count of quail occupancy of forties is the only objective measurement by which we can estimate quail production within specified limits of statistical precision." It must be concluded that the case for usefulness of numbers of whistling cocks in summer to estimate autumn populations is weak and that a better method is needed.

SUMMARY

Data from large and small areas, based on indices and direct counts, on the relationship of summer whistling to autumn populations of bobwhites were evaluated to ascertain whether counts of whistling quail provide a reliable estimate of fall populations. Such estimates have not yet proved to have a substantial statistical basis or to be sufficiently reliable for setting the length of the open season or establishing bag limits.

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SOME FOODS OF THE WHITE-TAILED DEER IN SOUTHERN ARIZONA[1]

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This paper presents information on the use of plants by white-tailed deer in Arizona, and the probable significance of these plants as indicators of range condition and trend. A study which began in July 1954 and terminated in January 1956 was the first in a series of studies on the white-tailed deer conducted by the Arizona Game and Fish Department and the Wildlife Research Unit.

Little has been published concerning the plants eaten by the Coues white-tailed deer (*Odocoileus virginianus Couesi*) in the Southwest. Nichol (1938) conducted a pen-feeding study of white-tailed deer in the Santa Rita Mountains of southern Arizona in which he tested the palatability of 168 species of native browse plants, forbs, and grasses. These tests showed that shrubs comprised a dependable and substantial part of the deer diet, but that trees, grasses, and annual plants were also important. From these experiments Nichol concluded that shrubby buckwheat (*Eriogonum Wrightii*) was the most important single shrub in the diet of the white-tailed deer.

In addition to information on comparative palatability as determined by penned deer, data on the plants eaten by wild white-tailed deer ad libitum are needed so that certain plants can be used as indicators of range condition. These data are also needed to evaluate the extent of competition for forage between livestock and deer.

The habitat of the Coues white-tailed deer in Arizona consists of isolated units in the higher desert mountain ranges in the southeastern part of the state. The deer occur at elevations from about 3,000 ft. to 10,000 ft. above sea level; vegetatively this altitudinal range varies from a desert-shrub association to a spruce-fir forest. Between the extremes are zones of oak–woodland (mostly *Quercus Emoryi, Q. arizonica, Q. oblongifolia,* and *Q. hypoleucoides*), pinyon–juniper (*Pinus cembroides* and *Juniperus Deppeana*), and yellow pine (*P. ponderosa*).[3] The lower elevations generally have high deer populations, and in some mountain ranges high populations of deer occur in the middle and higher elevations. Deer are usually numerous where mountains have comparatively broad tops as do the Chiricahua Mountains; but where mountains have narrow, steep tops, such as the Santa Rita Mountains, only a few deer are found at the higher elevations.

Microclimates caused by the direction of the slopes are important because the result is a wide variety of plants available at any one altitude.

Techniques of Study

During the course of the study it was not possible to collect sufficient stomach samples for reliable data; consequently the feeding-minute technique was used. Deer were observed feeding and the length of time that they fed on various plants was recorded. The feeding-minute as used in this paper is 1 minute of feeding by a single deer upon a single species of plant. This index has been used by various workers on different species of animals. In the 1920's and 1930's the feeding-minute method was used by the Soil Conservation Service on cattle and sheep in some of the western states. Dixon (1934) made an early appli-

[1] Contribution from the Arizona Cooperative Wildlife Research Unit; Arizona Game and Fish Department, University of Arizona, U.S. Fish and Wildlife Service, and Wildlife Management Institute cooperating.

[2] Now employed by the Arizona Game and Fish Department, Phoenix, Arizona.

[3] Plant names used in this paper are taken from Kearney and Peebles (1951).

cation of the method in the wildlife field in his study on mule deer in California. Buechner (1950) used this technique to study the foods taken by antelope in the Trans-Pecos area of Texas.

I recorded the accumulated time spent by a deer feeding on each species, as well as the number of plant contacts. A plant contact was one animal feeding continuously on a single plant species for an unspecified length of time. I recorded feeding time to the nearest 5 seconds. The plant on which a deer fed was not always visible but its identification was possible when the general area was properly located. When several contacts were made at the same time a small sketch map helped greatly in finding the exact location of the plant contacts.

Observations of wind direction and velocity, amount of cloud cover, type of clouds, and other weather phenomena were recorded. The only element that appeared to affect feeding adversely was high wind. I observed deer feeding during rain and thunderstorms as long as the wind remained relatively low. The only equipment needed to make timed observations was a pair of binoculars and either a stop watch or an ordinary watch with a sweep second hand.

The chief advantages of the feeding-minutes technique were that feeding data including basic diets, differences in the feeding habits of the sexes or age groups, and differences in elevational, geographical, or seasonal feeding habits could be gathered without collecting the deer.

Some obvious disadvantages included the following: (1) It required different lengths of time for a deer to consume equal volumes of different plants. (2) Study areas did not always contain the same food plants. (3) Feeding-minutes were difficult to obtain when deer fed in thick brushy areas. (4) Night feeding data could not be gathered. (5) Consumption of grass was hard to detect and harder to evaluate. Nevertheless it was felt that the advantages of this technique far outweighed the disadvantages and that the objectives of the study were met.

STUDY AREAS

The three main study areas were those listed below.

(1) *Florida Canyon, Santa Rita Mountains, 4,300-ft. elevation*—This area is at the junction of the desert–grassland and oak–woodland vegetative types. The dominant plants are Emory oak (*Q. Emoryi*), Mexican blue oak (*Q. oblongifolia*), mesquite (*Prosopis juliflora*), catclaw (*Acacia Greggii*), mimosa (*Mimosa dysocarpa*), and false mesquite (*Calliandra eriophylla*). Dominant grasses are the perennial grama grasses (*Bouteloua* spp.).

(2) *Canelo Ranger Station, Canelo Hills, 5,000-ft. elevation*—Some representative plants of this area are Emory oak (*Q. Emoryi*), Mexican blue oak (*Q. oblongifolia*), silk-tassel (*Garrya Wrightii*), mountain mahogany (*Cercocarpus betuloides*), and cliff-rose (*Cowania mexicana*), which form an open oak–woodland type. Dominant grasses are the perennial grama grasses.

(3) *Bar-Foot Park, Chiricahua Mountains, 8,500-ft. elevation*—The dominant plants of this type are yellow pine (*P. ponderosa*), silverleaf oak (*Q. hypoleucoides*), and netleaf oak (*Q. reticulata*). Grasses are represented by mountain muhly (*Muhlenbergia montana*) and pine dropseed (*Blepharoneuron tricholepis*). A fire burned over a portion of this site about 5 yr. prior to the study.

All three study areas are located within 50 mi. of the Mexican border and between Tucson on the west and the New Mexico state line on the east.

The summer climate of southeastern Arizona is controlled by the "thermal low" found in desert areas of the Southwest. Throughout the remainder of the year weather is dominated by the "Pacific high" with an occasional cold frontal passage in winter. The climate is typified by two rainy seasons and two dry seasons. Summer rains come as heavy thundershowers, while winter rains are of the slower, steady frontal type. The average annual precipitation, most of which falls during summer, varies

TABLE 1.—OBSERVED FEEDING TIME, COMPARATIVE AVAILABILITY, AND RELATIVE ABUNDANCE OF PLANT SPECIES UTILIZED

Plants Used	Total Time (min.:sec.)	Total Contacts	Availability		Abundance		
			Seasonal	All Year	High	Medium	Low
LOW ALTITUDE 6/15/55–2/1/56							
Non-leguminous browse plants							
Fouquieria splendens	85:20	58	+	–	+	–	–
Eriogonum Wrightii	27:25	14	–	+	–	+	–
Ferocactus Wislizeni	11:50	24	+	–	–	+	–
All others	33:20	30	various		[—— various ——]		
	157:55	126					
Leguminous browse plants							
Calliandra eriophylla	1177:45	267	–	+	+	–	–
Mimosa dysocarpa	644:20	322	–	+	+	–	–
Krameria parvifolia	256:50	87	–	+	–	+	–
All others	156:15	75	various		[—— various ——]		
	2235:10	751					
Forbs and Grasses							
Ipomoea longifolia	68:15	29	+	–	+	–	–
Bouteloua spp.	42:45	13	+	–	+	–	–
Cassia leptadenia	38:35	10	+	–	–	+	–
All others	66:10	44	various		[—— various ——]		
	215:45	96					
Subtotal	2608:50	973					
HIGH ALTITUDE 6/15/55–2/1/56							
Browse species							
Ceanothus Fendleri	93:55	23	–	+	+	–	–
Quercus hypoleucoides	8:35	5	–	+	+	–	–
Quercus Gambelii	:30	1	–	+	–	+	–
	103:00	29					
Forbs and grasses							
Delphinium andesicola	221:45	41	+	–	+	–	–
Agoseris sp.	95:05	26	+	–	+	–	–
Lupinus Blumeri	55:55	29	+	–	+	–	–
All others	65:30	30	various		[—— various ——]		
	438:15	126					
Subtotal	541:15	155					
Grand Total	3150:05	1,128					

from 11 in. in lower elevations to 27 in. on mountain peaks (Smith, 1956). Except at the higher elevations there is little snow. The yearly mean temperature varies from 44° to 65°F.; the lowest January mean in high altitudes is 27°F., the highest July mean in lower elevations is 88°F.

DISCUSSION AND RESULTS

Plants eaten by deer were assigned different classes of availability and abundance, based on field observations (Table 1). The listings are for the study areas only and are not necessarily representative of the entire mountain ranges. I obtained a total of 3,150 feeding-minutes and 1,128 plant contacts during the course of the study. Leguminous browse plants at the low altitudes were the most important forage. Of these, *M. dysocarpa* was the most important browse plant during the summer months. In October the deer began eating *C. eriophylla* frequently, and by December this plant had become the major item of diet.

TABLE 2.—THE WEEKLY RECORD OF TOTAL FEEDING TIME SPENT ON BROWSING OCOTILLO (*Fouquieria splendens*) AND THE RAINFALL FOR FLORIDA CANYON, SANTA RITA MOUNTAINS, 1955

Date	Percent of Total Feeding Time Spent on Ocotillo	Total Feeding Time (min.:sec.)	Rainfall (in.)
June 17–23	0	22:25	0.00
June 24–30	0	22:20	0.00
July 1–7	0	20:00	0.00
July 8–14[1]			0.60
July 15–21	86	51:50	1.21
July 22–28	44	92:45	1.81
July 29–Aug. 4[1]			1.24
August 5–11	4	85:10	3.36
August 12–18	2	64:30	2.01
August 19–25	0	11:10	4.59

[1] No plant observations made.

During the winter months, deer were often found on the open south-facing slopes where *C. eriophylla* and to a lesser extent *Krameria parvifolia* grew. These were extensively eaten by the deer.

Either when the growth of grass fails, or where its density is low, competition may become intense between deer and cattle for the leguminous browse species. The feeding on leguminous browse species constituted 86 percent of the total feeding-minutes gathered in the Canelo Hills and Santa Rita Mountains study areas. The presence of the leguminous browse species is of the utmost importance in lower altitudes where some of the highest densities of white-tailed deer occur. Many of these legumes rate high in food value. Although the number of stomach samples collected was small, the frequency of occurrence of *C. eriophylla* in these samples compared closely to the feeding-minutes data.

During November 1954 and November 1955, 10 white-tailed deer stomach samples were collected from areas similar in vegetative character to that of the Santa Rita study area. *C. eriophylla* was the only plant species occurring in all 10 stomach samples, and this single species accounted for 62 percent of the total feeding time during this period. All data gathered during this study point towards the great importance of both *C. eriophylla* and *M. dysocarpa* on ranges of white-tailed deer as represented by the low altitude study areas.

The browsed condition of *C. eriophylla* and *M. dysocarpa* can serve as a guide for evaluating the condition of the lower range; the ranges should be managed for these two browse species. This study did not include areas where mountain mahogany (*Cercocarpus* spp.) was the predominating forage plant. Areas of mountain mahogany growth cover considerable acreage around the 6,000- to 7,000-ft. level in portions of the white-tailed deer range and support a high deer density. According to Day and Welch (1959) mountain mahogany is the most important forage plant in these areas. Considering the wide altitudinal distribution of white-tailed deer in Arizona, it is obvious that no single plant species can serve as a range indicator for the entire region. Although *Eriogonum Wrightii* was the most preferred species in Nichol's pen feeding study, a high rate of use of this plant was not noted in the present study. This could be attributed to the fact that the relative abundance of *E. Wrightii* was low when compared with leguminous browse plants such as *C. eriophylla* and *M. dysocarpa*. Possibly overutilization of *E. Wrightii* has resulted in a decline in density of this species and a decrease in plant vigor affecting current annual growth.

Forbs in the lower ranges were of comparatively minor importance even though 1955 was an exceptional year for their production.

Deer sometimes ate fruit of the barrel cactus (*Ferocactus Wislizeni*). A deer would eat one or two fruits from a plant

TABLE 3.—SELECTION OF BROWSE, FORBS, AND GRASSES BY DIFFERENT CLASSES OF DEER, FLORIDA CANYON, SANTA RITA MOUNTAINS, AUGUST–DECEMBER 1955

Deer Class	Percent of Feeding Time			Total Feeding Time (min.:sec.)
	Browse	Forbs	Grasses	
Bucks	89	9	2	425:50
Does	94	4	2	863:30
Fawns	98	2	0	256:15
Unclassified	96	4	0	151:05

TABLE 4.—A COMPARISON OF UPPER AND LOWER RANGE DIFFERENCES IN SELECTION OF FORAGE PLANTS AS REPORTED BY PERCENTAGES OF FEEDING TIME, AUGUST–OCTOBER 1955

Month	Santa Rita Mountains (4,300 ft.)				Chiricahua Mountains (8,500 ft.)			
	Percent of Feeding Time			Total Time (min.:sec.)	Percent of Feeding Time			Total Time (min.:sec.)
	Browse	Forbs	Grasses		Browse	Forbs	Grasses	
Aug.	91	4	5	208:30	79	21	0	80:25
Sept.	45	51	4	139:55	8	87	5	208:15
Oct.	97	0	3	389:35	9	91	0	240:05

but ignore the species for the rest of the feeding period. A relatively large number of contacts was made on this species but the total feeding time was low.

Deer fed on some plants for short periods only, but at these times they were heavily used. Such plants may be important to deer even though they are not eaten during most of the year. Winter is the most critical time of the year over the majority of the range in the west and north, but in southern Arizona the period from late May to the middle of July is apparently most critical. This is the driest time of the year in southern Arizona and green forage is scarce. With the coming of summer rains in July new growth starts, but most plants do not react rapidly enough to furnish immediate green forage.

A common plant in the lower elevations is ocotillo (*Fouquieria splendens*), a plant which produces foliage quickly following the first rains. The leaves were heavily eaten by deer for a short period of time. In 1955 the first rains came on July 12 and 13. Until this time ocotillo was completely devoid of foliage; yet during the week of July 15–21, it was taken during 86 percent of the observed feeding time. Preference for ocotillo declined after July 21. In August it was taken only 2 percent of the time; in September it was not observed to be taken at all. The sudden rise and sharp drop of feeding time on ocotillo is shown in Table 2.

In the lower elevations there seems to be a higher consumption of forbs in early morning than in late evening. This is shown by the fact that on a monthly basis the percentage of total feeding time spent on consumption of forbs was always higher in the morning. Forbs are probably more succulent in the early morning during the period of highest relative humidity.

Use of forbs in higher elevations constituted a larger percentage of the total feeding time (Table 4) and extended over more days than in lower ranges. This greater use of forbs could be attributed to the fact that the more desirable browse species were not generally available in higher areas. Also forbs are greener for a longer period at higher elevations and thus remain palatable longer. Openings in the forest cover which permit the growth of forbs are probably important in maintaining deer herds in these higher altitudes.

No real difference in food selection was noted among bucks, does, and fawns (Table 3).

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SUMMARY

Food habits of white-tailed deer in southeastern Arizona were studied in three desert mountain ranges by the feeding-minute technique. A total of 3,150 minutes of feeding time and 1,128 plant contacts were

tallied during the time of this study.

In the lower elevations, leguminous browse species of the genera *Calliandra*, *Mimosa*, and *Krameria* were found to be key plants, and should be studied when evaluating range conditions in this region. Influence of spring drought on requirement for succulent vegetation is indicated by the pattern of use of *Fouquieria*. Forbs were taken most heavily in the high altitudes.

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SOME PARASITES AND DISEASES OF SNOWSHOE HARES IN NEWFOUNDLAND

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Beginning in 1954 and continuing until 1959, the senior author conducted an extensive study of the snowshoe hare (*Lepus americanus struthopus* Bangs) in Newfoundland (Dodds, 1960). This paper reports on one aspect of that study.

Helpful in providing information or assistance in this study were P. D. McKercher, H. C. Gibbs, R. McG. Archibald, and J. F. Frank, Health of Animals Division, Department of Agriculture (Canada); E. G. D. Murray, Collip Medical Research Laboratory, University of Western Ontario; and R. E. Phillips, Cornell University. O. H. Hewitt and B. V. Travis, Cornell University, are thanked for their critical readings of the manuscript.

MATERIALS AND METHODS

Of a total of 630 hares examined, 483 were from the Humber East, White Bay South, St. Barbe, and Grand Falls districts, and 147 were collected from Emberly Island, Placentia Bay.

Most of the animals were collected by snaring. The age composition was 311 adults (167 males, 144 females) and 319 juveniles (173 males, 146 females). The pooled seasonal distribution of collections was January-February, 34; March-April, 77; May-June, 132; July-August, 181; September-October, 90; November-December, 116.

Except for 12 animals sent to the Animal Disease Laboratory at Sackville, New Brunswick, no specimens were given complete and thorough post mortems. Three of the 12 hares examined at the Sackville laboratory were shipped alive from Newfoundland. Animals collected during the summer months were usually examined in the field. Hares taken when the weather was cool were normally brought to the Cormack field station for examination. Some animals were examined more thoroughly than others and this fact was noted on the individual data cards. Twenty-five blood smears from 17 live or freshly killed hares

TABLE 1.—INCIDENCE OF IMPORTANT SNOWSHOE HARE PARASITES BY AREA

Species	Area	Hares in Sample	Hares Parasitized	Percent Parasitized
Dicrocoelium dendriticum	Emberly Island	147	10	7[1]
Mosgovoyia pectinata	Humber East	203	35	17
Taenia pisiformis and *Hydatigera taeniaformis* (larvae)	Humber East and Eddie's Cove West	381	152	40
Obeliscoides cuniculi	Humber East	286	166	58
Obeliscoides cuniculi	Emberly Island	128	108	84
Obeliscoides cuniculi	Eddie's Cove West	17	15	88

[1] No adult flukes found in juvenile hares. Thirteen percent of adults infested.

were stained in Giemsa's. No blood parasites were found.

Endoparasites were initially preserved in 15 percent formalin. Nematodes were taken directly from the stomach or obtained by straining stomach contents. All helminths were removed to water prior to staining or examination.

Tapeworms that had become twisted or badly contracted were not identified. Nematodes, chosen at random and identified from only 60 animals, represented about 25 percent of the nematodes collected. A series of 16 vials believed to contain all of the species of helminths collected was sent to the Animal Disease Laboratory, Sackville, New Brunswick, for verification. Except for *Trichostrongylus axei*, which we did not find, all of their determinations corroborated our findings. A flea was identified by James Layne, University of Florida, Gainesville, Florida. E. W. Baker of the U.S.D.A., Agricultural Research Service, Bethesda, Maryland, kindly determined the single mite found.

PARASITES

TREMATODA.—*Dicrocoelium dendriticum* (Rudolphi), a common liver parasite of sheep and cows, was the only trematode found, and that from Emberly Island. Only adult hares were infested, comprising 7 percent of 147 animals (Table 1). On a seasonal basis trematodes were found in 2 of 14 hares in March, 5 of 47 in May, 2 of 4 in July, and only 1 of 12 hares in November. According to Krull and Mapes (1952, 1953b), animals become infested by eating ants, the second intermediate host of the fluke.

This trematode record appears to be the first for *Lepus americanus*. Krull and Mapes (1953a) mention *Lepus europaeus* and *Sylvilagus floridanus* as the only wild lagomorph hosts. Although snowshoe hares were introduced in March 1954 to Emberly Island, which lies approximately 5 mi. from the mainland, sheep have been present during the summer since the early days of settlement. Sheep were not examined for parasites.

The ecology of *Dicrocoelium* infections in snowshoe hares was not studied. There can be little doubt, however, that hares become infested by accidentally ingesting ants. Without specific data concerning the identity, ecology, and habits of the ant involved and its relation to the feeding habits of the host, it is impossible to comment further on the host-parasite relationship. A thorough survey from other sheep-farming areas might indicate that this parasite is common in Newfoundland hares.

It is improbable that *Dicrocoelium* is important as a decimating factor in hares. Lethal infestations of this trematode were not observed; it may be that this parasite contributes to weakening the resistance of a few individuals to other factors in the environment.

CESTODA.—Four species of tapeworms were found: *Mosgovoyia pectinata* (Goeze) (Syn. *Cittotaenia pectinata*), adult stage; larval stages of *Taenia pisiformis* (Bloch), *Hydatigera taeniaeformis* (Batsch), and *Multiceps* sp.

TABLE 2.—ANNUAL FREQUENCY OF OCCURRENCE OF IMPORTANT SNOWSHOE HARE PARASITES, HUMBER EAST AND WHITE BAY SOUTH DISTRICTS, 1955–1959

Year	*Taenia pisiformis* AND *Hydatigera taeniaformis* LARVAE			*Obeliscoides cuniculi*			*Mosgovoyia pectinata*[1]		
	Hares in Sample	Hares Parasitized	Percent Parasitized	Hares in Sample	Hares Parasitized	Percent Parasitized	Hares in Sample	Hares Parasitized	Percent Parasitized
1955	12	3	25				7		
1956	119	73	61	16	7	44	41	3	7
1957	60	30	50	60	26	43	27	4	15
1958	101	17	17	101	64	63	70	25	36
1959	111	34	31	111	60	54	73	3	4

[1] Juveniles only. Figures based on juveniles examined.

M. pectinata occurred in 17 percent of 203 Humber East hares (Table 1), but no adult hares were infested. These observations corroborate those of Chandler (1955), who mentions *Cittotaenia* as occurring only in young hares. According to Erickson (1944), infestation in young hares induces a high degree of immunity. As many as seven mature cestodes were found in a single animal. Although the duodenum, jejunum, and ileum were often distended and appeared occluded, the infested hares did not seem to be in poor condition. The greatest number of juveniles (36 percent) containing *M. pectinata* was found in 1958 following a decline in the hare population (Table 2).

All cestode larvae (bladder worms) in the muscles or on the viscera were determined as *Taenia* sp., and it was not until after the collections were made that it became evident that two genera were present. Consequently, specific data are not available regarding the respective incidences of *H. taeniaformis* and *T. pisiformis* larvae. Most of our larvae were of the strobilocercus type, which is characteristic of *H. taeniaformis*. Hook measurements from scolices of several larvae of both species fell well within the ranges given by Riser (1956) and Wardle and McLeod (1952). From D. A. Benson, former Provincial biologist in Nova Scotia, we learned that he obtained specimens of *H. taeniaformis* from a snowshoe hare in 1952; he was under the impression that his record was the first North American host record for snowshoe hare. It would appear that our observations constitute the second record. In Newfoundland, the wild definitive host of *H. taeniaformis* is probably the Newfoundland lynx (*Lynx canadensis subsolanus* Bangs), that of *T. pisiformis*, the Newfoundland fox (*Vulpes fulva deletrix* Bangs). No larval cestodes were found in hares taken from Emberly Island, where neither lynx nor fox are found.

Bladder worms were more common in adult hares than in juveniles. In some instances infestation was heavy. For example, over 300 larvae were removed from an adult female in which the tenderloin (psoas) muscles were reduced to a jelly-like consistency. Larvae were also present about the lungs and heart as well as lying free in the peritoneal cavity, on the liver, and imbedded in the mesenteries, particularly in the area of the spleen. This animal was in poor condition, as evidenced by the fact that there was no fat about the kidneys or between the shoulders where fat depositions are commonly found. Studies of *T. pisiformis* indicate that heavy infestations in rabbits (*Sylvilagus* sp.) may result in liver damage, lack of fat, and stunting of growth (Whitlock, 1939). Observations from the present study suggest that similar pathogenic conditions may occur in Newfoundland hares infested with bladder worms.

Encysted larvae of the genus *Multiceps* were observed in two hares from near St. John's, on the Avalon Peninsula. We were unable to identify positively these larvae to species. According to Honess and Winter (1956), *M. serialis* (Gervais) is most apt

to be the species found in wild lagomorphs. The definitive hosts are usually dogs and foxes. It is interesting that the only two cases of this cestode were from the St. John's area where the greatest density of dogs occurs. No cases of *Multiceps* were found in 50 hares skinned and examined from other study areas. In Minnesota, Erickson (1944) found *Multiceps* in 47 of 773 (6 percent) hares; in Ontario less than 10 percent of the hares were infested with this cestode larva (MacLulich, 1937).

NEMATODA.—Two strongylid nematodes, *Obeliscoides cuniculi* (Graybill) and *Trichostrongylus axei* (Cobbold), were found. *O. cuniculi,* the most commonly encountered nematode, occurred in 58 percent of the 286 hares taken in the Humber East district during the course of this study (Table 1). Infestations were lowest in 1956 and 1957, and highest during 1958 following a late season decline of hares in 1957 (Table 2). During the year of highest hare density, 1959, the percentage of occurrence was somewhat greater than the lower density years of 1956 and 1957. Erickson (1944) found the highest frequency of infestation during years of decline. It is probable that the frequency of infestation in Newfoundland hares also peaks during the early stages of declines, for the highest frequencies were observed in areas experiencing an annual population drop, Eddie's Cove West, and on Emberly Island (Table 1) where the population had recently crested.

More adult hares, 87 of 125 (70 percent), than juveniles, 71 of 161 (44 percent), were infested with *O. cuniculi* in the Humber East district. These observations corroborate those of Erickson (1944). Monthly rates of infestation appeared to vary considerably although the samples were, in most cases, too small to indicate trends. Erickson found March, May, July, and September to be peak months. In the present study, September appeared to be the peak infestation month for juveniles, but June and August were highest for adults.

Heavy infestations of *O. cuniculi* were often accompanied by blood clots and a sloughing of the stomach wall. Quantities of thick yellowish fluid were often found in the pyloric area. Infestations were considered "heavy" when 50 or more worms were counted. Although in the summer of 1959 as many as 200 worms per hare were found, populations of up to 4,000, as noted by Erickson (1944), were never encountered. In general the infestations seemed to approximate those found by MacLulich (1937) in his Ontario studies.

On the basis of their studies both MacLulich and Erickson consider *O. cuniculi* a contributing factor in hare declines. From the observations in the present study it seems likely that this parasite could be of importance in Newfoundland, perhaps in lowering the resistance of the host to bacterial infections, or possibly as a contributing factor toward physiological stress during high hare densities.

The second nematode, *Trichostrongylus axei* (Cobbold), was identified at the Sackville laboratory from one of two collections from Emberly Island. This is apparently the first time *T. axei* has been reported from the snowshoe hare; sheep, other ruminants, and horses are the usual hosts. This small nematode was not found in any of the hares from the mainland collection areas. The fact that large numbers of sheep graze on Emberly may explain the presence of this parasite in some hares collected there. Infestation occurs directly through ingestion of the larvae with vegetation.

ACARINA.—The common tick *Haemaphysalis leporis-palustris* (Packard) was found on 12 percent of 122 hares examined from May 1 through November in the Humber East district and 1 of 18 hares taken in the Eddie's Cove West area. It was the only species of tick found. *H. leporis-palustris* was also identified from the Avalon Peninsula and the Grand Falls area. Questionnaires to 34 resident rabbit catchers in this study indicate that ticks are widespread and common; from 1 to 28 ticks in various stages of development were collected per infested hare. MacLulich (1937) reported over 100 ticks per hare during high hare densities in Ontario.

Adult ticks were found on hares as late

as November 16 from the Humber East study area. In other areas they were found as late as November 14 and October 1. June and July were peak months for tick parasitism in the Humber East area. Seven of 18 hares examined closely for ectoparasites yielded ticks during this period. Except for the presence of small scars in the ears of some hares, these ticks did not appear to harm the host. Furthermore, the incidence of ticks was low in all areas studied. However, because *H. leporispalustris* is a known vector of tularemia (Matheson, 1950), and *Bacterium tularensis* has been reported from snowshoe hares (Philip, 1938), this tick must be considered a potential vector of the disease in Newfoundland.

A single unidentified nymphal mite of the family Parasitidae was collected from a hare in the Humber East area in 1958. This was probably an accidental occurrence since these mites are considered predators rather than parasites.

SIPHONAPTERA.—Of the 122 hares examined for ectoparasites in the Humber East area, only one provided a single flea. The flea, *Ceratophyllus garei*, is commonly found on ptarmigan in Newfoundland (S.S. Peters, personal communication) and may occur on other ground nesting birds (Holland, 1949). Our record for *C. garei* appears to be the first for snowshoe hare and perhaps the first for a mammal (Holland, 1949). It was undoubtedly an accidental occurrence on the hare and probably is unimportant as a mammal parasite.

DISEASES

LISTERIOSIS.—The bacterium *Listeria monocytogenes* (Murray) was reported by McKercher and Archibald (1959) from wild hares held in captivity during this study. Three hares were shipped alive to the Department Agriculture Laboratory at Sackville, New Brunswick, after deaths began to occur among captives and in the wild in the summer of 1958. All three of the animals exhibited symptoms of illness similar to those captives which had died. Cultures from liver and spleen from two of these animals revealed *L. monocytogenes*. The most outstanding gross lesion in rabbits was focal necrosis of the liver which usually produces small whitish spots throughout the liver tissue. The lesions in hares from which *Listeria* cultures were made were comparable to lesions observed in three of the four wild juvenile hares found dead and examined, and similar in appearance to lesions noted in eight juveniles which died in captivity during September 1957 and September 1958.

STRESS.—The influence of any of a number of stressers may alter endocrine activity, thus causing functional disturbances and lesions. In the broad sense, then, stress must be considered a disease.

Ten of 74 (14 percent) live-trapped hares (4 adults, 6 juveniles) were dead when the traps were examined, although in no case were traps left unattended more than 30 hr. and all were placed in protected areas with some birch twigs available inside. These animals were examined and appeared free of lesions. Three of the adults were trapped in February and March and one was taken in June. All juveniles found dead in traps were caught in July and August. The relative number of adults and juveniles live-trapped is not available, for age was undetermined during the winter and spring months. Adams (1959) found that 3 of 58 adults trapped (5 percent) and 25 of 101 (25 percent) juveniles trapped showed symptoms of a condition he called "trap sickness." The same stresser related to trapping may have been operative in both this and Adams' study.

Sixteen adult hares (about 40 percent) which were live-trapped and placed in captivity died within 30 days. These hares were free of lesions or heavy parasitic infestations. Stomachs were usually full, although on one occasion the stomach and most of the intestinal tract were empty. Nearly all of the 16 hares exhibited varying degrees of lethargy for as long as 20 hrs. prior to convulsions and death. These hares could be removed from the pens and handled with no effort on their part to escape.

SUMMARY

Six hundred and thirty snowshoe hares were examined for parasites in Newfoundland between 1955 and 1959. The following parasites were found: Trematoda, *Dicrocoelium dendriticum* (Rudolphi); Cestoda, *Mosgovoyia pectinata* (Goeze), *Taenia pisiformis* (Block), *Hydatigera taeniaformis* (Batsch), and *Multiceps* sp.; Nematoda, *Obeliscoides cuniculi* (Graybill), *Trichostrongylus axei* (Cobbold); Acarina, *Haemaphysalis leporis-palustris* (Packard); Parasitidae unidentified to genus, and Siphonaptera, *Ceratophyllus garei* Rothschild. The bacterium *Listeria monocytogenes* (Murray) was first reported for hares by McKercher and Archibald in 1959 from Newfoundland animals made available during this study. Snowshoe hare host records for the lancet fluke, *D. dendriticum*, the small hairworm, *T. axei*, and the flea, *C. garei*, are believed to be the first. Heavy parasitism from the common rabbit stomach worm, *O. cuniculi*, may reduce resistance and occasionally destroy individual hares directly. Hares were found dead in live traps and died in captivity during the study.

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DIFFERENTIAL HUNTER HARVEST OF ELK IN TWO MONTANA HERDS[1]

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Tagging programs over past years have provided a body of population information concerning the Sun River and Judith River elk herds of Montana. The Sun River elk herd consists of about 3,000 animals residing in the main range of the Rocky Mountains south of Glacier National Park. The range of this herd has been previously described by Picton (1960). The Judith River elk herd of about 1,000 animals ranges in an eastward extension of the Rocky Mountain cordillera in central Montana, known as the Little Belt Mountains. A partial description of this area has been given by Lovaas (1958). The two herds are separated by about 120 airline miles. Seven hundred and sixty-seven elk have been tagged in the Sun River drainage since 1937; 254 animals have been tagged in the Judith River area since 1953. This study was undertaken to estimate the population turnover among the tagged animals; information was also collected from untagged animals to provide some indication of whether or not the conclusions reached in the tagging studies were valid for the entire herds.

The author is indebted to the many workers, known and unknown, who have tagged animals in these areas. Among them were R. L. Brown, L. G. Casagranda, R. F. Cooney, F. M. Couey, R. L. Eng, B. A. Goodman, R. G. Janson, B. Neal, D. M. Neal, R. Neal, W. Perry, M. Rognrud, E. E. Rundquist, K. A. Rundquist, J. K. Saunders, R. L. Varner of the Montana Fish and Game Department. I also wish to thank Mrs. Mary Oliver, Montana Fish and Game Department, who assisted in compiling the tagging information, and Charles Mode of Montana State College, who reviewed the statistical techniques employed. This study was supported by project W-74-R of the Montana Fish and Game Department.

All of the Judith elk and 295 of the Sun River elk were captured in corral type traps and tagged with metal ear tags. Ages of trapped animals were determined by means of tooth replacement (Quimby and Gaab, 1957). Four hundred and seventy-two calves were captured and tagged in the Sun River drainage beginning in 1937. Recoveries of the tags from hunter kills were made at checking stations.

Eighty-three (33 percent) tags were recovered from the Judith River herd since 1953. During this period over 1,100 elk were harvested from the herd. In 24 years, 171 (23 percent) tags were recovered from the Sun River herd. At least 12,990 elk were harvested in this same period. Hunter interviews indicated little intentional selection of sexes or age classes.

Since ages were determined when the elk were tagged, it was possible to predict what the age composition of the kill of the tagged animals should have been if all age classes were equally vulnerable. Thus the basic assumption made in the prediction of the kill is that the kill of a given age class should be directly proportional to the number of animals of that age class which are hunted.

Calculations

Estimation of the Predicted Kill

Estimation of the kill (Table 3) from the data in Tables 1 and 2 was made in the following manner. In the Sun River during 1937 (Table 1) 17 female calves were tagged; if it is assumed that all lived, 17 would have been hunted as calves in the fall of 1937 and, since none were killed, 17 would have been hunted as yearlings in 1938. As 1 animal was killed in 1938, only

[1] A contribution from the Game Management Division, Project W-74-R, Montana Fish and Game Department.

TABLE 1.—NUMBERS OF CALVES TAGGED, NUMBERS AND AGES OF ELK RECOVERED FROM THE SUN RIVER ELK HERD

Year Tagged	No. of Females Tagged	No. and Ages of Females Recovered[1]	No. of Males Tagged	No. and Ages of Males Recovered[1]
1937	17	1–1½	17	1–3½; 2–5½; 1–7½; 1–13½
1938	44	1–½; 1–1½; 1–2½; 2–4½	41	2–½; 2–2½; 1–3½; 1–4½
1939	33	1–1½; 3–3½; 1–9½; 3–11½; 1–17½; 1–18½	21	3–1½; 1–2½; 1–3½; 1–4½; 1–11½
1940	18	1–1½; 1–6½; 1–18½	10	2–½; 1–2½; 1–6½; 1–10½
1941	13	1–6½	14	1–1½
1943	32	1–2½; 3–3½; 1–11½	42	1–½; 4–2½; 1–4½; 1–9½
1944	7	none	9	none
1945	15	none	19	2–2½; 1–5½; 1–6½
1946	11	1–½; 1–1½; 1–10½	15	1–1½; 1–3½
1947	13	1–8½	11	none
1948	10	none	10	none
1955	6	none	4	1–5½
1956	1	none	4	none
1957	5	none	8	1–1½
1958	5	1–1½; 1–2½	7	1–½
1959	5	none	3	1–½; 1–1½
1960	1	none	1	none

[1] Age in years.

16 would have been hunted as 2-yr.-olds in 1939. This procedure was followed for all years and all groups of animals. The "animal years hunted" shown in Tables 4 and 5 are the totals for each age class as derived in the described manner.

Obviously some method must be used to correct for natural mortality if the estimates of "animal years hunted" are to be accurate. Because the food supply of both herds is adequate and winter loss, at present, is very light, it was assumed that the loss of animals 2 yr. old and younger is negligible. Field examination of the few "winter killed" elk found suggested that the loss was almost entirely of old animals. Loss of newborn calves reduces the total recovery rate of the tags, but since it affects all age categories, its influence on the prediction of the kill is reduced. To correct the estimate of the adult category for natural mortality, the Sun River returns from elk tagged from 1937 to 1941 (Table 1) were plotted and fitted with a curve. The belief that the kill of adult animals (not younger animals) for any age class is directly proportional to the abundance of that age class is implicit in this procedure. To eliminate another source of error, the sex of the elk must be considered. The returns from 31 female and 42 male elk tagged as calves (Table 1) gave a mean life of 6.16 years for the females and 3.67 years for the males. As a result, different longevity curves were used for each sex. The number of animals entering their third year was multiplied by the following correction values to get the number surviving to that age: Females: 3½–.85; 4½–.74; 5½–.67; 6½–.62; 7½–.58; 8½–.54; 9½–.50; 10½–.44; 11½–.38; 12½–.34; 13½–.28; 14½–.22; 15½–.18; 16½–.14; 17½–.06; 18½–.03. Males: 3½–.80; 4½–.64; 5½–.50; 6½–.38; 7½–.25; 8½–.23; 9½–.18; 10½–.12; 11½–.08; 12½–.04; 13½–.02. The results were cross-checked to insure that the corrected numbers were in fact possible after the numbers of animals harvested were accounted for.

Comparison of Predicted and Actual Values

The "fit" of the actual kill to the predicted kill was compared by means of a Chi-square "goodness of fit" test (Ostle, 1954:64–66). The hypothesis that the distribution of the actual kill was the same or "fit" that of the predicted kill was rejected in both cases (Table 3).

TABLE 2.—NUMBERS AND AGES OF ELK TRAPPED, TAGGED, AND RECOVERED FROM THE TRAPPED ELK IN THE JUDITH RIVER AND IN THE SUN RIVER ELK HERDS

Year Tagged	No. of Females Tagged	No. and Ages of Females[1]	No. of Males Tagged	No. and Ages of Males[1]
		JUDITH RIVER		
1954	81	12–½; 6–1½; 63–mature	15	8–½; 5–1½; 2–mature
Recovered[2]		2–1½; 3–2½; 2–3½; 3–3½+; 1–4½; 4–4½+; 1–5½+; 1–6½; 7–6½+; 1–7½; 4–7½+		4–1½; 2–3½; 1–3½+
1955	28	3–1½; 25–mature	3	2–½; 1–mature
Recovered		2–3½+; 1–4½; 1–4½+; 2–5½+; 1–6½+		1–3½+
1956	47	7–½; 4–1½; 1–2½; 35–mature	18	12–½; 5–1½; 1–mature
Recovered		1–1½; 3–3½; 5–3½+; 3–4½+; 4–5½+; 1–5½		1–1½; 2–2½; 3–3½
1957	6	1–½; 2–1½; 1–mature	3	1–½; 2–1½
Recovered		1–1½		1–1½
1958	19	2–½; 2–1½; 6–2½; 9–mature	3	3–1½
Recovered		1–2½+; 2–4½; 2–4½+		1–2½
1959	16	1–½; 5–1½; 4–2½; 6–mature	3	1–NB[3]; 2–½
Recovered		1–1½; 1–2½; 1–2½+; 2–3½+		1–1½
1960	10	1–½; 3–2½; 6–mature	2	2–½
Recovered		2–4½+		none
		SUN RIVER		
1953	5	1–½; 4–mature	4	1–½; 3–mature
Recovered[2]		none		1–3½+; 1–4½+; 1–7½+
1954	13	2–½; 11–mature	11	11–mature
Recovered		1–2½+; 1–3½+; 1–7½+		2–3½+; 2–4½+
1955	15	3–½; 2–1½; 1–2½; 9–mature	18	2–½; 1–1½; 15–mature
Recovered		1–2½+; 1–3½+; 1–4½+; 2–5½; 1–5½+; 1–6½; 1–6½+		1–1½; 3–3½+; 1–4½+; 1–5½; 1–6½+
1956	1	1–½	14	1–1½; 13–mature
Recovered		none		6–3½+; 1–5½+
1957	62	2–½; 8–1½; 52–mature	12	5–½; 4–1½; 2–2½; 1–mature
Recovered		1–1½; 1–1½+; 1–2½; 10–2½+; 2–3½; 4–3½+; 3–4½+		1–2½; 1–3½; 1–4½+
1958	61	7–½; 2–1½; 52–mature	16	5–½; 7–1½; 1–2½; 3–mature
Recovered		3–2½; 2–2½+; 14–3½+; 2–4½+		1–1½; 5–2½; 2–3½; 2–4½+
1959	41	1–½; 1–1½; 3–2½; 36–mature	10	1–½; 4–1½; 1–2½; 4–mature
Recovered		1–2½; 3–2½+; 1–3½; 2–3½+		1–2½; 1–2½+; 1–3½; 1–4½+
1960	12	12–mature	0	
Recovered		1–3½+		none

[1] Trapped animals were classified by dentition (Quimby and Gaab, 1957) as calves, yearlings, 2½-yr.-olds, and mature animals.
[2] The + indicates a minimum age for elk handled as mature animals in calculations.
[3] Newborn calf.

Construction of the Life Tables

The probability of surviving was computed by using the formulas presented by Davis (1960). Life tables were computed (Davis, 1960) from each body of evidence and are presented in Table 4. Table 5 contains extrapolations from the life tables and gives a rough estimate of the age and sex distributions in the herds.

DISCUSSION

Quick (1958) found in his analysis of data from Anderson's roe deer study that males were more susceptible to hunters than females, and not all age classes were equally vulnerable. He further points out that the composition of the kill at a 25-percent harvest level differs from the actual composition of the herd.

TABLE 3.—COMPUTATION OF PREDICTED KILL AND COMPARISON WITH ACTUAL KILL OF TAGGED ELK FROM THE JUDITH RIVER AND THE SUN RIVER ELK HERDS

	Adult	2-year-olds	Yearlings	Total
	JUDITH RIVER			
Female				
Animal years hunted	700	40	24	764
Percent of total years	91.6	5.2	3.2	100
Predicted kill	61	3	2	66[1]
Actual kill	57	4	5	66
Male				
Animal years hunted	106	34	28	168
Percent of total years	63.7	20.2	16.1	100
Predicted kill	11	3	3	17[1]
Actual kill	7	3	7	17
Chi-square				
Computed	10.37			
Tabular	7.78 (0.1 level, 4 d.f.)			

	Adult	2-year-olds	Yearlings	Calves	Total
	SUN RIVER				
Female					
Animal years hunted	1,935	252	249	236	2,672
Percent of total years	72.5	9.4	9.3	8.8	100
Predicted kill	66	9	9	8	92[1]
Actual kill	75	8	7	2	92
Male					
Animal years hunted	924	245	239	233	1,641
Percent of total years	56.3	14.9	14.6	14.2	100
Predicted kill	45	12	11	11	79[1]
Actual kill	46	17	9	7	79
Chi-square					
Computed	10.81				
Tabular	10.6 (0.1 level, 6 d.f.)				

[1] To eliminate a possible source of error, the actual numbers of males and females killed were used as the total predicted kill.

Inspection of the information from the Sun River herd (Table 3) suggests that the major portions of the Chi-square value were contributed by the calf groups and the 2-yr.-old male group. The differences between the actual and predicted values in the calf groups may be due to mortality or loss of the tags before the first hunting season. It was mentioned earlier that the effect of calf mortality would be reduced because it lowers the tag recovery rate for all groups and not just for one age-sex class. While the effect is reduced, it is not eliminated, because both animals tagged as calves and those that were trapped and tagged are lumped together. Comparison of tag recovery rates does suggest that newborn mortality or tag loss is a factor in comparisons of actual kill to predicted kill. The 472 Sun River elk which had been tagged when newborn gave an overall recovery rate of 15.5 percent. Calves (30) that were trapped and tagged during their first winter when about 6 mo. old gave a recovery rate of 23.5 percent. Thirty yearlings gave a recovery rate of 47 percent, and 236 elk older than yearlings gave a recovery rate of 33 percent. Another hypothetical factor which may be present is suggested by Taber and Dasmann's (1954) observation that the male fawns of black-tailed deer tend to stray farther from their mothers than the female fawns. In some years (Tables 1 and 2) the kill of 2-yr.-old males appears unusually

TABLE 4.—PROBABILITIES OF SURVIVAL AND LIFE EXPECTANCIES FOR THE JUDITH RIVER AND SUN RIVER ELK HERDS AS COMPUTED FROM SAMPLES OF TAGGED ANIMALS

	JUDITH RIVER				SUN RIVER			
	Male		Female		Male		Female	
Sample size	13		12		42		31	
	P[1]	R[2]	P	R	P	R	P	R
Age classes								
Calf	—	1,000	—	1,000	.83	1,000	.93	1,000
Yearling	.61	660[3]	.75	810[3]	.80	830	.80	930
Two years	.63	403	.78	608	.65	546	.87	744
Three years	—	254	—	474	.78	426	.83	647
Life expectancy at 2 yrs.	2 yr.		4 yr.		4 yr.		5 yr.	
Half-life[4]	2.5 yr.		4.5 yr.		3 yr.		4.5 yr.	
Three-fourths-life[4]	3.5 yr.		5.5 yr.		5.5 yr.		9 yr.	

[1] Probability of survival.
[2] Number of animals remaining from every 1,000 births.
[3] Tagged newborn calves were not available so the elk surviving to be yearlings were estimated from a sample of untagged elk.
[4] Half-life is the time required for half the population to die and three-fourths-life is the time required for three-fourths of the population to die. (Davis, 1960.)

high. While the 24-yr. average minimizes this trend, it still contributes one-fifth of the total or "pooled" Chi-square value (Table 3). Altmann (1960) indicates that there is some carryover of juvenile behavior into the 2-yr. age group.

The Sun River hunting seasons have remained similar over the years, either-sex seasons with the seasons being closed when the desired quota of elk had been taken. The usual season in the Judith area has been a short 2- or 3-day either-sex season followed by about a month of bull season. Occasional antlered-bull-only seasons have also been held in the Judith area.

Inspection of the information from the Judith River herd (Table 3) indicates that almost half of the total Chi-square value is contributed by the yearling male group. All but one of the tagged yearling males were killed after the either-sex season. A possible reason for this yearling male kill is that during the bull season the yearlings are often found with the large cow-calf herds ranging nearer to the main roads and below the heavier snow levels. This fact would tend to make the yearling males easier to locate and more accessible than the small groups of adult males. Altmann (1960) indicates that there is differential behavior of the yearling age class. Anderson (1958) reports that yearling males make up about one-third of the bulls killed by hunters from the Jackson Hole herd in Wyoming. Yearlings made up about a quarter of the total male kill in the Judith River herd and about half of the males older than calves that are killed. In the Sun River herd yearling males made up a little less than a fifth of the total male kill and about a quarter of the males older than calves.

In the Judith River herd 37.5 percent of the tags from 51 calves tagged during their first winter were recovered. Thirty-nine elk tagged as yearlings gave a recovery rate of 36 percent. The recovery rate from 164 elk older than yearlings when tagged was 30.5 percent.

Males made up 50.4 percent of the 472 calves tagged on the calving grounds of the Sun River since 1937. There was considerable apparent variation in the calf sex ratio over the years. Of 228 calves tagged from 1937 to 1941, only 45.3 percent were males. During the following 5 yr., 1942 to 1946, when 150 calves were tagged, the sex ratio reached the opposite extreme of 56.1 percent males. The tagged samples represent less than 5 percent of the estimated calf crops during the two periods. The sex ratios of the trapped animals showed a heavy preponderance of females, as was predicted from the location of the traps. Analysis of the tag returns (Table 6) showed

TABLE 5.—AGE AND SEX DISTRIBUTIONS IN THE SUN RIVER AND JUDITH RIVER ELK HERDS AS EXTRAPOLATED FROM LIFE TABLES FOR THESE HERDS (Table 4)

	SUN RIVER		JUDITH RIVER	
	Male	Female	Male	Female
Percent calves	9	9	13	13
Percent yearlings	8	8	9	11
Percent 2 years	5	7	6	8
Percent 3–10 years	15	29	9	26
Percent over 10 years	2	8	0	5
Total	39	61	37	63

that the kill was heavier with males than the original tagged samples of both the trapped animals and the calves. This shift indicates that the males were harvested from the herd at a more rapid rate than the females. It is probable that the shift in sex ratios would be reduced in well-harvested herds that have little mortality other than that due to hunting.

As Table 5 was computed from small samples (Table 4), it is desirable to check the results with field data collected from the two herds. Table 5 indicates that the calf crop of the Sun River herd should equal 35 percent of the females older than calves. Classification of 3,660 elk killed during the last 6 yr. gave a comparable figure of 35 percent of the cow herd. Five years of winter field classification data have indicated a calf crop of 31 percent. Table 4 indicates that the number of males older than calves in the kill should be about 89 percent of the number of females older than calves. The comparable value from the harvest classifications was 80 percent males for the 6-yr. period. Table 5 indicates that the calves should equal 52 percent of the cow herd in the Judith River herd. Classification of 422 elk harvested in the last 4 yr. gave a comparable figure of 49 percent calves. Three years of winter field classifications gave a figure of 50 percent calves. Table 4 indicates that the number of males older than calves in the kill should be about 75 percent of the females older than calves. Harvest information over 4 yr. gave a value of 56 percent males during the either-sex season, with post card questionnaire surveys indicating a considerable rise in this bull:cow ratio during the bull season.

Thus Table 5 indicates that the effect of the more rapid turnover of males is to make them a minority in the population. This agrees with field observations of herd composition. Cowan (1950) and others have reported the heavy preponderance of females in various herds of cervids. As indicated by Klein and Olson (1960), most of these records are from herds on poor range. The winter range of the Judith River herd rates "good" by the Cole (1957) key-species-bunchgrass method and the Sun River winter range rates "fair." Both ranges are improving and winter loss of animals is negligible.

The maximum longevities recorded during this study were two 18½-yr.-old cows and a 13½-yr.-old bull from the Sun River herd.

TABLE 6.—A COMPARISON OF SEX RATIOS OF ANIMALS TAGGED, AND RETURNS FROM THESE ANIMALS FOR BOTH THE SUN RIVER AND THE JUDITH RIVER ELK HERDS

	Sun River	Judith River
Number of animals tagged	767	254
Tagged as newborn calves	472	1
Percent males	50.4	—
Animals trapped and tagged	295	253
Percent males	28.8	18.2
Tag returns		
From animals tagged as newborn calves	73	0
Percent males	57.5	—
From animals tagged in traps	98	83
Percent males	38.7	20.5

SUMMARY

An analysis of information from 254 tag returns from known-age elk suggested a disproportionate harvest of males from both herds. The most heavily harvested group in the Judith River herd appeared to be the yearling males. Tag loss or natural mortality of newborn calves apparently contributes to the discrepancy between the predicted and actual kill for the Sun River herd. Males made up 50.4 percent of 472

Sun River calves tagged. There was considerable apparent variation in the sex ratios of calves tagged during the 24-yr. study period. The maximum longevities were two 18½-yr.-old cows and a 13½-yr.-old bull from the Sun River herd.

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EVALUATION OF THE INFLUENCES OF WOODY COVER ON PHEASANT HUNTING SUCCESS[1]

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During the past 15 years, wildlife habitat improvement projects have been initiated in most sections of the North American pheasant range. Among the many benefits attributed to such programs was the possibility that hunting success would be improved even if plantings had no influence on pheasant production or survival. The objective of the study reported here was to measure and evaluate the effects of woody windbreak plantings during the hunting season in northeastern Colorado.

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STUDY AREAS

Since 1949, habitat-development projects of the Colorado Game and Fish Department have distributed about 2 million seedling trees and shrubs for use in wildlife cover plantings. A number of types of plantings have been established, but the most common have been four- to seven-row wind-

[1] A contribution of the Federal Aid in Wildlife Restoration Act, Colorado Project W-90-R. Also part of a dissertation submitted to the University of Michigan, Ann Arbor, Michigan.

breaks up to about ½ mi. long. Study areas for evaluation of these windbreaks were selected on the basis of available plantings. All woody cover on slightly over a million acres of high plains wheatland in northeastern Colorado was plotted, and wherever a proper combination of plantings occurred, a nine-section (5,760 a.) study area was established.

All study areas were mapped to determine annual land-use patterns, which for three consecutive years showed slightly over 96 percent of the total land area used productively and nearly 90 percent of this total devoted to wheat, fallow, and pastureland. Correlation analyses testing for relationships between woody cover plantings and land-use patterns demonstrated no significance.

A total of 29 areas in 5 counties was available for study, but only the areas in Sedgwick, Phillips, and Logan Counties were used in the hunting investigation. Three classes of study areas were examined in 1955 and four classes in 1957. "Heavily developed" areas were those on which 12–15 a. of woody cover of both windbreak and thicket types were present. "Nine-planting" areas had approximately 10 a. of woody-windbreak cover and "six-planting" areas approximately 7 a. Control areas were those on which no woody cover was present.

SURVEY METHODS

For the purposes of this study, pheasant hunting success was measured in terms of the number of cock birds killed per hour of hunter effort. On each study area, one man contacted all hunters and determined, as closely as possible, the number of pheasants shot and the total gunning pressure. The mean kill per hour was then calculated for each area, and these means were compared to determine the influence of various combinations of plantings on the harvest.

In 1955, the first year of the study, 14 areas, in three classes, were surveyed on the second day. The study was not continued beyond the second day of the 20-day split season because hunting pressure thereafter was too light to provide reliable information. Legal shooting began at 12 noon, November 11, and surveys were mostly continued until the 5 p.m. closing.

The 1956 survey was cancelled because an early season snowstorm completely blocked all roads in the study region for nearly a week. In 1957, 11 areas were surveyed on the opening day of the season and 6 on the second day. Legal shooting began at 10 a.m., November 9, and surveys were continued until the 5 p.m. closing.

HUNTING SUCCESS

The compiled data for the opening days of the two hunting seasons (Table 1) demonstrate that more pheasants were killed, and the return per unit effort was greater, where woody windbreak plantings were present. The average kill per hour on developed areas ranged from 1.5 to 3.6 times as great as the average on control areas, and in both years the differences were directly proportional to the intensity of habitat improvement.

Second-day data for the two hunting seasons are not presented here because they add nothing to the basic conclusions. The data indicated that any influence of windbreak plantings on hunting success was probably confined to the opening day. In both years, hunter success was slightly greater on the more heavily developed areas, but the differences among density groups were not significant.

ANALYSIS

In attempting to delineate the absolute influence of woody plantings on hunting success, it was necessary, first, to evaluate the differences in hunting pressure among study areas. In 1955, linear correlation between *Effort* and *Harvest* was 0.955,[2] and in 1957, 0.816. If $100r^2$ is taken as an esti-

[2] This statistic and all others evaluating the small samples of the hunting season data have been adjusted for sample size using methods described by Ezekiel (1941). For these data, adjusted $r^2 = 1 - (1 - r^2)\ [(n - 1)/(n - m)]$ where n = the number of observations and m = number of constants represented in the regression equation.

TABLE 1.—TOTAL HUNTER EFFORT, NUMBER OF PHEASANTS KILLED, AND AVERAGE KILL PER HUNTER-HOUR (14 nine-section areas in 1955 and 11 areas in 1957; opening day of the pheasant season, northeastern Colorado)

Study Area	1955			1957		
	Effort (hunter-hours)	Harvest (pheasants killed)	Success (birds per hour)	Effort (hunter-hours)	Harvest (pheasants killed)	Success (birds per hour)
Heavily developed areas = 12–15 a. of woody plantings						
1	54.25	27	.498	133.33	75	.562
2	20.25	11	.543	—	—	—
3	39.25	19	.484	—	—	—
Nine-planting areas = approximately 10 a. of windbreak plantings						
4	12.00	6	.500	21.35	7	.328
5	5.58	1	.179	—	—	—
6	106.75	61	.571	137.00	72	.526
7	16.83	4	.238	34.43	12	.349
8	79.33	2	.025	40.00	12	.300
9	14.50	2	.138	—	—	—
Six-planting areas = approximately 7 a. of windbreak plantings						
10	—	—	—	50.67	22	.434
11	—	—	—	100.33	28	.279
12	—	—	—	63.17	31	.491
Control areas = no woody cover						
C-1	46.50	8	.172	36.00	9	.250
C-2	12.00	3	.250	127.58	24	.188
C-3	9.25	2	.216	9.83	10	1.017
C-4	25.50	0	.000	—	—	—
C-5	16.42	2	.122	—	—	—
Means of subgroups						
Planting density						
Heavy	37.92	19.0	.501[1]	133.33	75.0	.562
Nine	39.17	12.7	.323	58.19	25.8	.442
Six	—	—	—	71.39	27.0	.378
None	21.93	3.0	.138	57.80	14.3	.248

[1] Mean *Harvest* divided by mean *Effort*.

mate, variation in hunting effort accounted for 91.2 percent of all variation in *Harvest* in 1955 and 66.7 percent in 1957. Data from areas 8 and C-4 in 1955 were deleted from these calculations because they were considered to be unreasonably deviant. These two areas were the only contiguous plots in the investigation. The fact that both produced exceptionally poor harvests in response to above average hunting pressures suggests a localized non-random influence of a type not associated with the normal patterns of hunting effort and harvest.

Using the pooled data for both years of study, $r = 0.882$, and approximately 78.0 percent of the pheasant harvest was determined by hunting effort. But, within the individual density classes, the regression of *Harvest* on *Effort* was nearly absolute. Correlation between *Harvest* and *Effort* on the heavily developed areas, for example, was 0.997, and the standard error of estimate was 2.57 birds. On nine-planting areas, $r = 0.984$, and on control areas, $r = 0.902$. Standard errors were, respectively, 3.87 and 3.60. The only exception to this accuracy of prediction was found in the sample involving areas with only six plantings. The three observations had a correlation coefficient of 0.000 (unadjusted $r = 0.421$), and the standard error of estimate was 7.20 birds.

Thus, the number of pheasants killed on any particular area was largely determined by the total hunting effort expended, but the amount of time invested in each bird was either determined by woody cover or

TABLE 2.—PRESEASON PHEASANT POPULATION DATA (Totals of 4 crowing counts on each of 12 nine-section study areas in 1955 and 11 areas in 1957, northeastern Colorado)

Area	YEAR	
	1955	1957
Heavily developed areas		
1	125	255
2	95	—
3	40	—
Nine-planting areas		
4	106	212
5	12	—
6	61	225
7	54	148
8	—	131
9	27	—
Six-planting areas		
10	—	225
11	—	105
12	—	83
Control areas		
C-1	70	117
C-2	43	105
C-3	81	187
C-5	78	—

influenced by some factor associated with woody cover. Several factors, including preseason pheasant populations, acreages of all agricultural crops, and estimates of available edge, were tested for correlation with hunter success. Only the data describing preseason pheasant populations are presented here (Table 2) because none of the other tests produced correlation coefficients significantly greater than zero.

Pheasant Populations

Pheasant populations on the study areas of this investigation were censused using both spring-crowing and fall-roadside counts. For a variety of reasons, most of which have been described by Fisher, Hiatt and Bergeson (1947), crowing counts were considered to be the more reliable. Two-minute, early morning counts were taken at two points on each study area three times during the period from April 15 to June 15 each year. The two highest counts from each point, a total of four counts, were combined as estimates of pheasant population densities (Table 2). No adjustments for possible sex-ratio and production differences were attempted because the correlation calculated with crowing counts was greater than that calculated with roadside counts. After correction for sample size, correlation between crowing counts and hunter success was $r = 0.444$. This value, while significantly greater than zero ($t = 2.27$ with 22 d.f.), demonstrates a relationship which is extremely weak by comparison with the *Effort* relationship.

Regression Adjustment

Multiple regression methods, described by Anderson and Bancroft (1952), were utilized in determining the combined influence of hunting-effort and pheasant-population variations on the harvest. With 23 sets of observations from both years, linear correlation between *Effort* and *Harvest*, adjusted for sample size, is .883, and correlation between crowing counts and *Harvest* is .471. Combining both factors in a multiple regression analysis, with *Harvest* as the dependent variate and *Effort* and *Counts* as independent variates, multiple $R = .890$. This coefficient of multiple correlation indicates only a slight, and certainly not significant, improvement in prediction over the regression equation based on *Effort* alone. The standard error of the partial regression coefficient for *Effort* (.0546) is relatively small, but the error for *Counts* (.0344) is large enough to suggest that *Counts* may actually make no real contribution to the regression. Nevertheless, it seems obvious that hunting success cannot be divorced from population differences, and for this reason, *Counts* are included in the analyses and evaluation which follow. The least squares equation describing the simultaneous linear regression of *Harvest* on *Effort* on *Counts* is

$$H' \text{ (predicted harvest)} = -6.377 + 0.418\,Effort + 0.051\,Counts.$$

The two points necessary to establish regression lines for each of the planting-density groups may be determined by substituting group means in the above equa-

TABLE 3.—REGRESSION EQUATIONS ADJUSTING *HARVEST* FOR VARIATIONS IN HUNTER EFFORT AND PRESEASON PHEASANT POPULATIONS (23 nine-section study areas and various groupings of areas according to density of woody plantings, opening days of the pheasant seasons, 1955 and 1957, northeastern Colorado)

Treatment and Regression Equations	Mean $Y - Y'$
Basic equation	
$Y' = -6.377 + .418\ (\pm\ .0546)$ *Effort* $+ .051\ (\pm\ .0344)$ *Count*	
All areas, $N = 23$	
$Y' = -6.377 + .418\ (48.14) + .051\ (112.39) = 19.48$	0.0[1]
Heavily developed areas, $n = 4$	
$Y' = -6.377 + .418\ (61.77) + .051\ (128.75) = 26.0$	7.0
Nine-planting areas, $n = 9$	
$Y' = -6.377 + .418\ (43.16) + .051\ (108.44) = 17.2$	2.5
Six-planting areas, $n = 3$	
$Y' = -6.377 + .418\ (71.39) + .051\ (137.67) = 30.5$	−3.5
No-planting areas, $n = 7$	
$Y' = -6.377 + .418\ (36.80) + .051\ (97.29) = 14.0$	−5.7

[1] $Y - Y'$ for an individual study area is the deviation from the regression, and, since the regression is a least-squares fit, the sum of the 23 $Y - Y'$ differences must equal zero.

tion and assuming that the regression must pass through the zero point, *i.e.*, that no *Effort* will yield no birds. Although forcing a regression through origin is admittedly artificial, the procedure does not appear to be unsound because the predicted *Harvest* for zero *Effort* at the mean *Count* for this equation is −0.6 bird.

For the four heavily developed areas, $H' = -6.377 + 0.418$ (mean *Effort*, 61.77) $+ 0.051$ (mean *Count*, 128.75) $= 26.0$. But the mean harvest on heavily developed areas was actually 33.0 birds. The difference between actual and predicted harvest, 7.0 birds, is a deviation which cannot be accounted for by either hunting effort or preseason pheasant population differences. The five comparable regression solutions, including the *Harvest* $- H' = 0$ equation for all 23 study areas, are presented in Table 3.

These differences between actual and predicted harvest are not directly comparable because they are based on unequal amounts of hunting effort. If, however, they are converted to an equivalent hunting pressure, they provide a means of estimating the influence of woody cover on hunting success on opening day of the hunting season. At a mean effort of 40 hunter-hours, for example, the difference between actual and predicted harvest on the heavily developed areas is 4.5 birds; for areas with nine plantings, 2.3 birds; for areas with six plantings, −2.0; and for control areas, −6.2. This means that if an average of 40 hunter-hours is applied to all areas, a heavily developed nine-section area will produce 10.7 more birds than an unimproved area on the opening day of the pheasant season. An area improved with nine woody plantings will yield 8.5 extra birds, and an area with only six plantings will produce 4.2 additional birds. The important point to recognize is that a basic yield of 9.9 birds (predicted mean harvest, 16.1, less 6.2 = mean harvest on controls) will be taken from any area with 40 hunter-hours of effort and that additional birds represent an increase in harvest due solely to influences of woody plantings.

The influence of woody cover on hunting success at other levels of hunting effort, in terms of deviations from expected total kill, may be expressed either tabularly (Table 4) or graphically (Fig. 1). These estimates are most accurate below about 70 hunter-hours because the available data are concentrated below that point.

Evaluation

Conversion of the data in Table 4 to a cash basis requires (1) a reasonable explanation for an increase in harvest where no

TABLE 4.—DEVIATIONS FROM MEAN HARVEST, ESTIMATES OF TOTAL HARVEST ON NINE-SECTION AREAS ACCORDING TO DENSITY OF HABITAT-IMPROVEMENT, AND INCREASE IN HARVEST ATTRIBUTED TO PLANTINGS, OPENING DAY OF THE PHEASANT SEASON, NORTHEASTERN COLORADO

Item	HOURS OF HUNTER EFFORT					
	20	40	60	80	100	120
Deviation from mean harvest on						
Heavily developed areas	2.3	4.5	6.8	9.1	11.3	13.6
Nine-planting areas	1.2	2.3	3.5	4.6	5.8	7.0
Six-planting areas	−1.0	−2.0	−2.9	−3.9	−4.9	−5.9
Control areas (no plantings)	−3.1	−6.2	−9.3	−12.4	−15.5	−18.6
Number of birds killed on						
Heavily developed areas	10.0	20.6	31.2	41.9	52.5	63.1
Nine-planting areas	8.9	18.4	27.9	37.4	47.0	56.5
Six-planting areas	6.7	14.1	21.5	28.9	36.3	43.6
Control areas (no plantings)	4.6	9.9	15.1	20.4	25.7	30.9
Increase in kill caused by						
Heavy development	5.4	10.7	16.1	21.5	26.8	32.2
Nine plantings	4.3	8.5	12.8	17.0	21.3	25.6
Six plantings	2.1	4.2	6.4	8.5	10.6	12.7

basic differences in pheasant populations exist, (2) an estimate of the costs of woody plantings, and (3) an estimate of planting longevity.

The source of the additional birds in the harvest is fairly easily explained when it is realized that hunting has never removed a significant proportion of the annual pheasant production in northeastern Colorado. For nearly a decade, field men have reported post-season sex ratios between 1♂:1♀ and 1♂:3♀. Since ratios of 1♂:5♀, or higher, have no apparent effect on the breeding potential or fertility of pheasants, it is obvious that harvests have been inadequate. The increase in harvest, then, is simply the result of a more efficient harvest.

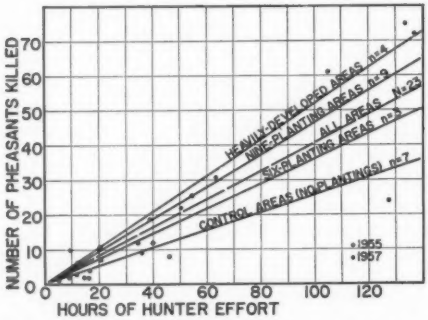

FIG. 1. Regression of pheasants killed on hunting effort, adjusted for preseason pheasant population differences.

Estimates of average cost for plantings similar to those investigated were supplied by Francis Metsger of the Colorado Game and Fish Department. The following data are based on prices and planting programs used by the Colorado Department in 1957 and 1958:

Heavily Developed Plots
(within 9-section areas) $800.00
Cost estimate based on intensive development of small areas of publicly owned land with all work done by Department personnel. Includes 5,000 seedlings, 60 hr. of ground preparation, 6 man-days planting, cultivation for 2 years, gasoline, depreciation of equipment, etc.

Windbreak Plantings
(per 9-section area)
Nine windbreaks $213.00
Six windbreaks $152.00
Cost estimates based on seedling distribution through SCS Districts, with labor and equipment furnished by landowners. Includes 3,820 or 2,550 seedlings, labor for handling and delivery, and gasoline and depreciation on delivery vehicles.

TABLE 5.—TWENTY-YEAR INCREASE IN PHEASANT HARVEST RESULTING FROM WOODY IMPROVEMENT PLANTINGS ON NINE-SECTION AREAS, AND AVERAGE COST OF EACH BIRD (Improvement expenses are $800 for a heavily developed area, $213 for nine windbreak plantings, and $152 for six windbreak plantings)

Item	AVERAGE HUNTER EFFORT (hours)					
	20	40	60	80	100	120
Total additional harvest on						
Heavily developed areas	108	214	322	430	536	644
Nine-planting areas	86	170	256	340	426	512
Six-planting areas	42	84	128	170	212	254
Average cost per bird						
Heavily developed areas	$7.41	3.74	2.48	1.86	1.49	1.24
Nine-planting areas	2.48	1.25	0.83	0.63	0.50	0.42
Six-planting areas	3.62	1.81	1.19	0.89	0.72	0.60

No comprehensive studies of the ages of established windbreak plantings on the Great Plains have been made, but Knott and Ball (1955) estimated the useful life of a woody habitat-improvement planting in Washington State at 20 yr., and there is no good reason to reject this figure. Thus, for approximately 20 yr., woody plantings will produce increases in the total harvest equivalent to those listed in Table 4. The original cost of the plantings, divided by the additional harvest, gives an estimate of the price the Game and Fish Department is paying for each bird delivered to the hunter. These calculations are presented in Table 5.

DISCUSSION

The estimated cost of a pheasant brought to the hunters' bag by habitat-improvement plantings ranged from 42 cents to $7.41. In comparison, the actual costs of producing a cock at a game farm range upward from $1.76, and the actual cost of a bird in the bag may be as high as $20.00 or more (Allen, 1956). Even if it is assumed that game-farm birds could be released immediately before the gun to guarantee a high return, habitat plantings are a better investment for Colorado. Further, if any value at all is attributed to the esthetic aspects of pheasant hunting, the wild birds must be considered a fundamentally more satisfying and desirable target than propagated birds.

Before attempting to apply cost estimates produced by this study to management, it should be pointed out that a number of liberties have been taken in the calculations. The assumptions made appear to be valid for northeastern Colorado, but their general application to the North American pheasant range may be limited.

First, and most important, the data have no application where post-season sex ratios indicate a cock harvest approaching annual production. In such areas, hunting success might possibly be improved by woody cover, but no increase in total kill can be expected if all of the naturally produced birds are already being harvested.

Second, the cost-estimate calculations assume that all land areas will receive the same hunting effort and that this effort will remain constant for the life of the plantings. There is some justification, based on comparison of the average effort within sampled groups, for assuming equal effort on all areas, but the second assumption is not valid. Current growth of the human population leads to predictions of increased hunting pressures nearly everywhere, and, conversely, weather conditions, as in 1956, can reduce hunting pressure to almost zero.

Third, the calculations assume an annual stability in the pheasant population which does not exist. This may be unimportant where the annual harvest is far below production, but it must be recognized that the regression has an upper limit; and that limit will be reached at much lower levels of hunter effort in years of production failure.

Finally, although the linear model provides a good fit for these data, there is no

reason to assume linearity at higher levels of hunting effort. There is every probability, in fact, that the true regression relationship would be curvilinear if data describing hunting pressures of 500 or 1,000 gun-hours were available.

Within these limitations, woody windbreak plantings can be a valuable pheasant management tool in the dryland areas of northeastern Colorado, and, possibly, elsewhere. In an underharvested population, pheasant hunting can be significantly improved by woody cover, and the improvement can be accomplished on an economically sound basis.

SUMMARY

Hunting-season data collected on 23 nine-section (5,760 a.) study areas in 1955 and 1957 are analyzed to determine the influence of woody windbreak plantings on hunter success. After adjustment for differences in hunting effort and pheasant populations among areas, it is shown that more birds are killed with less effort where woody plantings are present. Over a 20-yr. period, the additional birds taken from an underharvested pheasant population are harvested for approximately $1 apiece in habitat development funds.

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BRIEFER ARTICLES

A TECHNIQUE FOR WINTER TRAPPING OF RUFFED GROUSE[1]

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Although Ralph T. King was quite successful in winter trapping ruffed grouse (*Bonasa umbellus*) at the Cloquet Forest Research Center in the period 1931–34, subsequent investigators in other parts of the country either have not attempted extensive winter trapping of this species (Fisher, 1939), or have had little success in doing so (Bump, *et al.*, 1947:717; Dorney and Mattison, 1956; Eng, 1959:7; Dorney and Kabat, 1960:10). A technique used at the Cloquet Forest Research Center, near Duluth, Minnesota, during the fall and winter of 1959–60 makes winter trapping of this grouse nearly as successful as winter trapping of pheasants, quail, and other granivorous upland game species.

BAIT

The use of shelled corn, dyed and swollen to resemble the wild fruits ruffed grouse feed upon in the late summer and fall, is the basis for this technique. The berry-like shape and color of the corn apparently induce the grouse to try this otherwise unfamiliar food for the first time; once they find corn is palatable, grouse return day after day to fill their crops. Even 2 months after baiting has ceased at trap-sites, fresh tracks in the snow show where grouse have alighted near a trap-site, walked to it, and flown away when they found no corn.

Ralph T. King (verbal communication) used shelled corn to trap ruffed grouse at the Cloquet Forest from the fall of 1931 to the spring of 1934. To determine proper spacing of traps he used shelled white, yellow, and red corn and blue

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"Indian" corn, finding colored fragments of the pericarps from the corn kernels in grouse droppings. Using corn, King (MS.) recorded at least 809 grouse captures in about 3,673 trap-days' effort, for a success of about 4.5 trap-days per grouse taken. By season, his success was 5.6 trap-days per capture in 291 trap-days from November 8, 1931 to February 3, 1932; 4.6 trap-days per capture in 1,544 days' effort from December 10, 1932 to April 16, 1933; and 4.4 trap-days per capture in 1,838 trap-days from January 24 to March 31, 1934.

Yellow shelled corn was first tried in the present study during the fall and winter of 1958–59, with only limited success. During 148 trap-days' effort from November 25, 1958 to March 12, 1959, only 19 ruffed grouse were taken, for a success ratio of 7.8 trap-days per capture.

Observations during this period suggested that colored droppings might be produced by grouse feeding upon dyed corn, and movements from specific trap-sites could be plotted by locating these droppings. When fall trapping started in October 1959, dyed corn was offered as bait. Quickly the grouse found these traps and began feeding on the colored corn. Soon grouse were not only depositing brightly colored droppings, but were using traps in larger numbers and more persistently than previously.

Corn dyed orange, red, blue, or purple proved to be more acceptable than either undyed yellow shelled corn, or corn dyed green or yellow (the latter dyed to produce yellow droppings instead of white droppings resulting from undyed corn). Success at traps baited with either green or yellow (dyed or undyed) corn dropped off quickly, but picked up again within 2 or 3 days after being rebaited with corn dyed one of the preferred colors. I also found that use of a trap-site could be re-established within a few days after the trap had been unbaited for a month.

In the fall and winter of 1959–60, although the grouse population was about equal in size to that of the preceding year, 297 trap-days' effort with the use of dyed corn produced a catch of 104 grouse. This success ratio of 2.8 trap-days per bird taken was nearly three times better than the success a year earlier using undyed corn.

In the fall of 1960, using dyed corn, 154 days of trapping effort provided 49 grouse captures, a success of 3.1 trap-days per bird taken. However, this trapping session ended before the normally most productive portion of the trapping season had begun.

DYES USED

Dyes successfully used to date have included rhodamine B (red), methyl violet, Nabor orange (these have been supplied by both Allied Chemical Corporation and E. I. DuPont de Nemours & Company, to whom I am grateful), and DuPont's series of "Sevron" textile dyes, including orange G, blue B, yellow R, and brilliant red B.

An orange dye was also made by mixing auramine (yellow) and rhodamine B, but although the corn was bright orange, the grouse droppings were not as brightly colored as from corn dyed with Allied Chemical's Nabor orange R. Auramine and a fluorescein-Na salt have both been used for yellow. Although the fluorescein-dyed corn produces the best yellow dropping color, it appears to have a diarrhetic effect upon grouse in the field. A fast green FCF dye was used to dye corn bright green, but this color failed to show in droppings.

Dye solutions have been made by dissolving about 2 g. of powdered dye in 150 cc. of ethanol, and mixing this solution with hot water in 2-gal. pails not quite filled with shelled corn; DuPont's "Sevron" dyes are best dissolved in warm water, at the rate of about 2 g. of powder to 2 gal. of water. The mixture is left in a warm location for about 24 hr. to allow the dye to penetrate and the corn to swell. The solution is poured off and the corn permitted to freeze to retain its berry-like appearance.

I have no information on possible toxicological effects of these dyes upon grouse; however, at the end of April 1961, at least 9 grouse were surviving which had fed heavily on dyed corn 6 to 18 mo. earlier.

TRAPS USED

I used the "lily-pad" (Addy, *et al.*, 1956, Fig. 24) or shorebird trap first described by Low (1935), modified for use with ruffed grouse according to Liscinsky and Bailey (1955). The problem of keeping the fish netting top intact became acute in the face of heavy trap use by snowshoe hares (*Lepus americanus*), red squirrels (*Tamiasciurus hudsonicus*), and flying squirrels (*Glaucomys* sp.). To increase trapping efficiency the fish net was replaced with wooden-framed panels of 1-in. poultry netting, 2 × 6 ft. in size. Each trap requires three panels. Conifer boughs are placed over the screen panels to discourage grouse from flushing against the screen and becoming injured. In addition, covering the traps appeared to make the birds feel more secure, as well as sheltering bait from frequent snowfalls. Grouse often use unbaited bough-covered trap-sites for day roosts.

The first snowfall in 1959 provided evidence that many more grouse were feeding in traps than were being caught. A simple "swinging-wire" gate (Addy, *et al.*, 1956, Fig. 31) was placed at each entrance to the "lily-pad" and trapping success more than tripled (from 3.4 to 0.97 trap-days per grouse taken).

TRAP-SITE PREPARATION

The most rewarding winter trap-sites are those properly prepared and baited several weeks prior to the first persistent winter snow cover. After 2 to 4 in. of uncrusted snow covers the ground at the Cloquet Forest ruffed grouse seldom come to the ground, except to burrow in the snow for roosting, and the likelihood of their finding newly estab-

lished trap-sites becomes quite remote. However, grouse will fly to within a few yards of a known baited trap and walk into the trap.

Establishment of winter trap-sites early in the fall presupposes a knowledge of winter concentration areas and movement patterns of the grouse. Traps which are placed only a few dozen yards from normal wintering areas may not be found, even when placed early in the fall.

Traps, complete with wings, in place and baited while grouse are moving on the ground, are usually soon discovered. Once use by ruffed grouse has begun, the birds will return day after day, and actual trapping can be done whenever convenient.

Experiences during the fall and winter of 1959–60 and the fall of 1960 indicated a definite trap shyness by ruffed grouse. The highest success (42 grouse taken at a rate of 1.6 trap-days per bird) occurred the first day the traps were set, following periods of two or more days during which grouse had unrestricted egress from traps. The second day's trapping success dropped to 4.2 trap-days per grouse taken, the third day to 6.4 trap-days per capture; but on the fourth day the success rose to 2.6 trap-days per bird, and fell back to 4.0 trap-days per capture on the fifth day.

By taking advantage of this behavior, an operator can use 2 groups of 8 to 10 traps each, alternating 3 days open and 3 days set between the 2 groups. This regimen permits the operator to have as many as 16 to 20 traps functioning during the same period while maintaining the highest trapping success. After 2 or 3 weeks of alternating operation of these two groups, the trapper can move holding cages and top panels to another two groups of traps, to commence the same alternating operation in another area. He can return a month or so later to retrap with the first two groups.

With proper access and a sufficient number of traps (40 to 60), it may be possible to trap the majority of the ruffed grouse on an area such as the 3,300-acre Cloquet Forest Research Center during one winter. In most situations virtually every grouse in a wintering flock is trapped in 1 or 2 weeks.

SUMMARY

The use of corn, dyed orange, red, blue, or purple as bait in "lily-pad" (shorebird) traps at sites prepared before snowfall, has proven a highly successful winter trapping technique for ruffed grouse at the Cloquet Forest Research Center, Minnesota. Techniques of dyeing and swelling shelled corn, as well as trapping methods, are described.

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RESULTS OF CAPTURING WATERFOWL IN MINNESOTA BY SPOTLIGHTING[1]

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The capturing of waterfowl by use of lights is a technique that was used successfully for many years by poachers and commercial hunters, and more recently has been used by banders. A summary of spotlighting techniques used and results obtained is given in Section 2460, "Lights at Night," in U.S. Fish and Wildlife Service *Guide to Waterfowl Banding* (1956). Correspondence with William Leitch of Ducks Unlimited and Oliver Hewitt of Cornell University, both of whom have used lights in capturing waterfowl, further suggested the basic spotlighting technique which we utilized in Minnesota.

During the first season we used a portable 110-v. generator as a power source for photoflood lamps and spotlights. Few ducks were captured, however, because of the cumbersome equipment and the difficulty in maneuvering it. In addition, the photoflood lamps caused excessive backlighting which enabled the ducks to escape. In 1958, by

[1] Contribution from Pittman-Robertson Project W-11-R. Minnesota Division of Game and Fish, St. Paul, Minnesota.

TABLE 1.—SPECIES OF WATERFOWL CAPTURED BY SPOTLIGHTING IN MINNESOTA, 1958–60

Species Captured	1958	1959	1960	3-Year Total
Ducks				
Green-winged teal	3	3	0	6
Blue-winged teal	103	74	43	220
Ringneck duck	22	37	50	109
Mallard	31	38	40	109
Redhead	11	29	39	79
Canvasback	32	26	20	78
Ruddy duck	7	1	2	10
Lesser scaup		0	9	9
Gadwall	1	0	1	2
Pintail	5	6	4	15
Baldpate		1	0	1
Goldeneye		0	1	1
Totals	215	215	209	639
Others				
Coot	160	46	4	210
Grebe	25	5	2	32
Merganser		1	2	3
Totals	185	52	8	245

using a lighter, safer unit and by restricting our lights to spotlights, we were successful in capturing enough waterfowl to demonstrate the value of the technique in banding operations.

EQUIPMENT AND METHODS

Following is a description of the spotlighting equipment which proved to be efficient and safe for capturing waterfowl at night.

The portable electrical generating unit consisted of a small 2-hp., 4-cycle horizontal-drive gasoline engine, and an automobile generator and a 6- or 12-v. regulator, mounted on a suitable wooden platform. This unit produced between 180 and 360 watts depending upon type of generator utilized.

Three auto spotlights were used on the 180-watt units without a significant candle power reduction in any of the lights, and the illumination was sufficient for all spotlighting needs. A spotlight mounted on a headband and two lights in separate handgrips produced the most efficient arrangement. All lights had easily accessible separate switches. A heavy-duty automobile battery was used as an emergency light source both for spotlighting and for illumination while banding captured birds.

A 12-ft. aluminum boat driven by a 3-hp. "weedless" outboard motor proved to be a stable and maneuverable craft from which to net ducks. A dip net with a 6-ft. handle and 24-in. hoop with a 3-ft. bag of 1-in. mesh worked very well. As ducklings were removed from the dip net, they were placed in a 36- × 24- × 16-in. waterfowl holding crate with its opening covered by two overlapping pieces of automobile tire tubing.

The actual process of approaching and capturing ducks is carried on by a two-man crew. The netter, seated in the front of the boat, uses the head lamp and one of the hand spotlights. The motorman, who operates both the outboard motor and the electrical generating unit, manipulates the second spotlight. The search for broods is best effected by following the outer edge of any emergent vegetation at three-fourths to full outboard motor speed. All lights are in use until a brood is spotted; then the lights are switched off except for the head lamp of the netter. The dip net is readied during the last 50 yd. and the motorman maneuvers at about half speed so that the approach is made with the brood to the left of the bow. The outboard motor is turned off as the boat draws alongside of the brood and the net is brought down over the ducks' heads. As the netter transfers captured ducks to the holding crate, the motorman turns on his light, starts the outboard motor, and attempts to locate some of the ducks that were missed. These birds are picked up one by one. The first approach is usually the most successful and often results in a multiple catch. If the attending female is not captured on the first run, it is usually impossible to take her.

Success in capturing waterfowl by the spotlighting technique is due, in part, to the fact that the birds are temporarily blinded by the lights and are apparently not frightened by the steady engine noises. On an area not previously spotlighted, feeding activity of a hen and brood appeared to increase greatly as the boat first approached, and when the boat was within 10 yd. the brood usually formed a compact group. All of the ducks appeared to be calling, but nothing could be heard over the roar of the two motors.

In some cases when two or three half-grown young were approached, they swam directly toward the light. Some older non-flying young made shallow dives after being missed several times by the netter. Their course could be followed readily under water. Birds capable of flying were often netted. Sometimes sleeping birds were picked up prior to their awakening. Many other semi-aquatic birds and mammals were closely approached and could have been captured.

RESULTS

Spotlighting has been used for capture of flightless young ducks for a period of 3 years as a supplement to drive-trapping. The number and species of birds captured are given in Table 1.

During this 3-year period approximately 473 man-hours (39 nights) were spent capturing, marking, and banding 639 ducks. Success, which was best on calm, warm, overcast nights, averaged 1.3 ducks per man-hour. This is slightly better than the average number of ducks taken by a three- or four-man drive-trapping crew in the same general area. The spotlighting method of capturing waterfowl is a good technique which can be used concurrently with drive-trapping, especially on larger areas where drive-trapping is difficult.

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DEPOSITION AND DECOMPOSITION OF FECAL PELLETS BY COTTONTAILS

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Variability in the number of fecal pellets dropped by cottontails (*Sylvilagus floridanus*) and in decomposition rate of pellets in the field are factors influencing the accuracy of the pellet method of censusing. The purpose of our study was to determine the average number of fecal pellets produced daily by caged cottontails when fed excesses of different foods, and to determine the length of time necessary for these pellets to decay completely, with consideration of the effects of diet and environment on decay rates.

Several different daily averages of fecal droppings are reported in the literature. Trippensee (1938) found that two adult cottontails produced an average of 265.6 fecal pellets per 24 hr. during a 20-day trial. Hendrickson (1939) reported the average number of pellets dropped by a caged cottontail between 3 and 4 weeks of age to be 320 pellets per day. Dalke and Sime (1941) during experiments on food habits of cottontails (*S. floridanus* and *S. transitionalis*) found that four rabbits provided with a diet of bark, twigs, and buds averaged 450 ± 20, 505 ± 26, 496 ± 18, and 514 ± 17 pellets per day respectively, for a period of 44 days.

The authors wish to express thanks to the National Science Foundation (Undergraduate Research Participation Program) which provided the necessary funds for the study, to Mark Anthony who helped in the study of pellet size, to the U.S. Public Health Service for the loan of cages, to the School of Agriculture, Southern Illinois University, for cooperation in securing the necessary foods, and to the Department of Zoology, Southern Illinois University, for the use of its facilities throughout the study.

Materials and Methods

Eight young cottontails, four males and four females probably born in April or May, were captured in live traps and transferred to metal cages. Two of the rabbits died shortly after July 1, 1959, when the study began.

The cages were placed in a quiet room and no attempt was made to handle the animals at any time other than when the cages were cleaned. The cottontails were provided daily with food and water in excess of their needs. A commercial rabbit food (Ralston Purina Co., St. Louis, Mo.) in pellet form was used through most of July 1959. Toward the end of July, soybean and alfalfa plants were fed to some animals. Soon after cutting, these plants were stored in a refrigerator to insure freshness and to eliminate daily collecting. Rye plants, and sumac and plum twigs, treated similarly, were fed to some rabbits during the winter months. Corn kernels were shelled from the cob before feeding.

Each rabbit was given a single type of food at a time and usually two cottontails were fed each type of food. At least two rabbits, not necessarily the same two, were fed commercial pellets throughout the study. Whenever a cottontail was changed from one food to another, commercial pellets were given for a few days; no counts were recorded during these intermediate periods. In this way, all rabbits started a new food after having had the same base food.

Daily counts were made of the fecal droppings for each kind of food after it was fed an initial period of 3 days. This delay allowed previous foods to pass from the digestive system.

The greatest cross-sectional area of pellets was estimated by a dot-grid method, and these measurements were recorded in numbers of dots per pellet.

To observe decomposition, on three occasions we removed 150 to 200 fecal pellets of each food type from the trays under the cages and placed these pellets in selected areas (high grass, woods, fence row, and open field) in the field. The pellets were counted each week until they had decomposed beyond recognition. Usually pellets formed from two different foods were placed in each area to compare their decomposition rates. Wire cones, approximately 18 in. high and 12 in. in diameter at the base, were constructed from ½-in. hard-

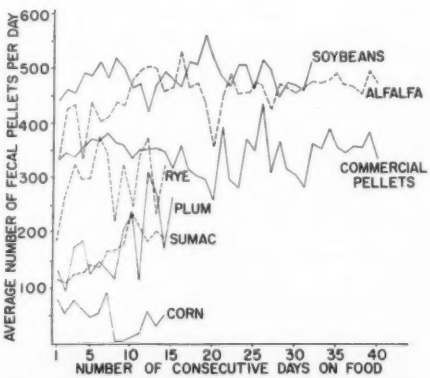

Fig. 1. Daily deposition of pellets by cottontails fed various foods.

TABLE 1.—DEPOSITION OF FECAL PELLETS BY RABBIT AND TYPE OF FOOD

Type Food	Rabbit Number	Days Fed	Avg. No. Pellets Deposited Daily (± SE)	Range of Daily Counts
Soybeans	1	32	594± 8.6	490–681
	2	32	441±11.3	314–560
	3	18	417±11.0	315–500
	7	18	512±13.9	400–600
	8	18	416± 9.2	353–520
	All	118	486± 8.3	314–681
Alfalfa	1	37	501±12.9	318–618
	2	37	419± 9.3	266–506
	3	37	469±11.9	307–640
	5	35	444±11.0	310–569
	6	35	438± 8.0	260–537
	All	181	455± 5.3	260–640
Commercial pellets	1	110	384± 8.3	185–545
	2	102	354±11.2	0–687
	3	29	317±28.1	0–515
	4	7	436±49.5	235–640
	5	45	412±15.6	96–605
	6	47	266± 5.0	188–318
	7	82	311± 7.1	10–442
	8	74	357± 8.5	135–485
	All	496	350± 4.5	0–687
Rye	1	14	258±17.6	144–346
	2	5	290±37.9	135–370
	7	14	327±16.4	263–446
	8	5	227±10.5	187–251
	All	38	292±12.8	135–446
Plum	5	15	193±24.7	98–375
	6	15	171±14.7	61–226
	All	30	179±14.6	61–375
Sumac	1	10	111± 8.9	73–181
	2	10	178±32.9	74–377
	3	7	188±21.0	115–299
	5	7	96±11.8	52–159
	6	8	109± 8.8	70–150
	7	10	264±17.5	185–338
	8	20	134±13.6	19–217
	All	155	155± 9.5	19–377
Corn	1	15	53± 8.6	3–100
	2	23	42± 9.0	0–185
	5	7	57±11.9	16–109
	6	4	66±22.1	24–140
	8	7	86±20.2	17–186
	All	56	54± 6.2	0–186

ware cloth and placed over each group of pellets to prevent their being disturbed by larger animals.

DEPOSITION OF PELLETS

Table 1 lists the average number of fecal pellets deposited daily by each rabbit which was given various foods at several times during the year. Therefore, the averages obtained represent combinations of various time periods throughout the year. There was considerable variation in the average number of pellets deposited by different rabbits even though they were essentially the same age and size and were feeding on the same food. For example, rabbit No. 6 deposited a daily average of 266 fecal pellets over a period of 47 days when fed commercial food, while rabbit No. 5 deposited a daily average of 412 pellets over a period of 45 days on the same food. This great difference in numbers of pellets deposited may have been because of a difference in the size of the pellets. The only measurement of size taken was an estimate of the greatest cross-sectional area. A sample of 100 pellets from each of these 2 rabbits showed a mean of 12.9 ± 0.5 dots for rabbit No. 5 and 14.9 ± 0.4 dots for rabbit No. 6. The difference between the area of these two samples of pellets was highly significant. Yet measurements of pellets of rabbits Nos. 2 and 8 also showed a highly significant difference in size even though the pellet numbers were similar (354 *vs.* 357). Pellets from rabbits Nos. 1 and 7 were not significantly different in size although there was a significant difference in the average numbers of pellets produced.

All comparisons made above were from pairs of rabbits of similar weights but different sex. No significant difference was found in area or number of pellets according to weight of the rabbit or sex alone. The data were from a small sample taken in the spring of 1960. If samples had been taken throughout the study, and if weights of pellets had been taken rather than area, there might have been demonstrated a closer correlation of pellet size with pellet number.

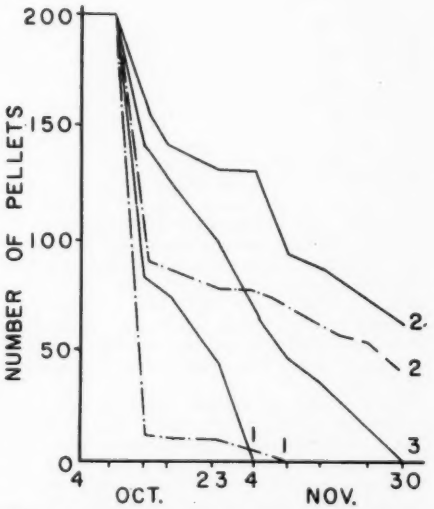

FIG. 2. Weekly counts of remaining rabbit pellets in woods (1), fence row (2), and mowed field (3). Solid line, pellets formed from commercial food; dash-dot line, pellets formed from alfalfa.

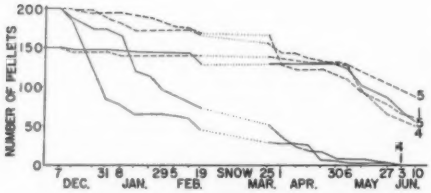

FIG. 3. Weekly counts of remaining rabbit pellets in woods (1), open field (4), and high weeds (5). Solid line, pellets formed from commercial food; dashed line, pellets formed from sumac.

Perhaps physiological differences are the basic cause of different numbers of pellets being produced. These differences in pellet numbers not only exist between rabbits but vary from day to day for the same rabbit. Rabbit No. 1 for example, had one period of 15 days with a daily average of 453 pellets and another of 10 days of only 286 in two feedings of commercial foods at different times of the year. Also, daily extremes ranging from no pellets to 687 pellets were exhibited by rabbit No. 2 (on commercial food) during the same feeding period. Large variations also occurred with other foods. The variation in the daily fecal pellets indicates the improbability of predicting the deposition rate of any one rabbit for one particular food on any one day. Any attempt to apply individual daily averages to a census formula could only lead to erroneous results.

Considerable variation appears in the overall average number of fecal pellets deposited daily by different rabbits fed different foods. However, pellet averages for soybeans and alfalfa are consistently higher than others such as sumac and corn (Table 1).

To arrive at a daily average number of fecal pellets deposited by all cottontails when fed a specific food, the days each rabbit was fed this food were numbered consecutively, and an average from all rabbits was calculated for each day (Fig. 1). Considerable fluctuation in the overall daily averages of pellets deposited by rabbits fed each food is notable. However, averages for rabbits fed some foods are consistently high. For example, daily averages for rabbits fed soybeans are consistently higher than those for rabbits on commercial food and much higher than those fed plum, sumac, or corn.

To determine the average deposition rate by all rabbits for each food, the daily rates shown in Fig. 1 were averaged. This resulted in one number for all rabbits for each food type (Table 1).

For the various types of food, fecal pellets deposited varied considerably in visual size and general appearance. Pellets deposited by cottontails feeding on soybeans, alfalfa, and commercial food pellets were generally round with a dark brown or black color. Rabbits feeding on plum branches and sumac deposited relatively large, round, light brown or tan fecal pellets. Rye produced fecal pellets that were small and distinctly black, often having a shrivelled appearance, similar to raisins. Pellets obtained from rabbits feeding on corn usually were extremely small with little consistency in shape. There were periods, however, when the same rabbit on the same food deposited pellets of radically different sizes during the same 24-hr. period. When this occurred, the count usually decreased. In general, the largest pellets came from rabbits fed wild plum (16.0 ± 0.4 dots), followed by those fed commercial food (14.7 ± 0.2 dots) and rye (12.9 ± 0.2 dots), with corn (12.0 ± 0.2 dots) producing the smallest pellets. There seems to be no correlation between size of pellets and numbers produced when different foods are considered.

Although these experiments demonstrate the tremendous variability in numbers of fecal pellets produced and thus should cause concern about use of fecal pellets in census techniques, at the same time the results obtained from commercial feed suggest the feasibility of making population estimates from the number of pellets. The daily variation of the average number of pellets produced over long periods of time tends to remain close to the mean of 350 ± 4.5. If the commercial food pellet approaches a balanced diet for the cottontail and if it can be assumed that, at certain seasons at least, a balanced diet is maintained in the wild, perhaps the variation is not large and an estimate of the population size is possible. Studies in the wild need to be made before any conclusions should be drawn, however.

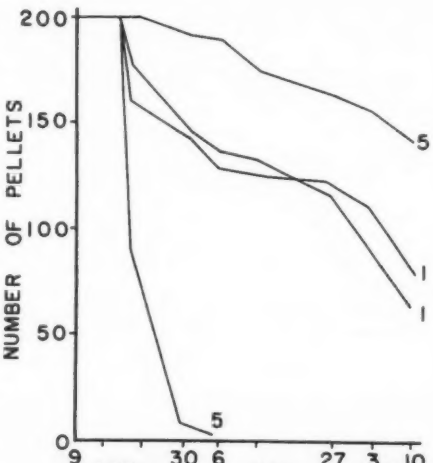

FIG. 4. Weekly counts of remaining rabbit pellets in woods (1) and high weeds (5). All pellets formed from commercial food.

DECOMPOSITION OF PELLETS

One of the objectives of this part of the study was to observe pellets almost daily for the first 2 weeks in an attempt to determine whether one could distinguish some change in the appearance of the pellets by which one might classify them as "fresh" or "old." This objective was not achieved since rain or other moisture often restored the glossy "fresh" appearance to the fecal pellets even though they may have been in the field for 2 or more months. Further, frozen pellets maintained a "fresh" appearance for many weeks.

Fig. 2 shows the results of the first study of decomposition rates. The weather was still rather warm (50 to 70°F) with no sustained freezing temperatures and the pellets decomposed rapidly. The least decomposed pellets were formed from commercial food and located in a fence row; these were more than 70 percent decomposed after 2 months. Pellets located in woods decayed much faster than those in the open field or along the fence row, and those pellets formed from alfalfa decomposed faster than those from commercial food.

The second study of decomposition rates ran from November 30 to June 11. Many pellets still remained at the termination of this study (Fig. 3), even though they had been in the field well over 6 months. The temperature during much of this period was below 40°F. Fecal pellets from rabbits fed sumac tended to decay at a slower rate than did those pellets formed from commercial food.

The third study of decomposition rate (Fig. 4) was undertaken to re-examine the decay rate during the warmer months (60 to 80°F.). Pellets for this test were placed beside those still in the field from the previous study. One group of pellets located in high weeds was quickly removed by scarab beetles. The rapid disappearance of some of the pellets in the first experiment (Fig. 2) also may have been due to insects, but no direct evidence of this was gathered.

These studies of the rate of decomposition indicate that fecal pellets decay or disappear at varying rates, depending especially on temperature, the location of the pellets, the type of food from which the pellets were derived, and possible utilization by invertebrates. Taylor and Williams (1956) also found that decay rates and general appearance of fecal pellets varied considerably with type of food eaten by rabbits and the location of pellets in the field. In our three studies, more than half of the pellets remained from 2 weeks to as long as 5 months.

SUMMARY

The daily deposition rate of pellets varied considerably from rabbit to rabbit (0 to 687 pellets), from food to food, and from time to time with the same rabbit on the same food. Cottontails on a diet of soybeans deposited the most pellets; those fed corn deposited the least. The decomposition rate of rabbit pellets varied with location, temperature, composition of the pellets, and disturbance by invertebrates. In general, more than 50 percent of the pellets remained from 2 weeks to as long as 5 months. Aging of the pellets seems to be impossible by visual means.

Present census techniques utilizing rabbit pellets probably are highly inaccurate although perhaps of some value as an index to populations. More basic work is needed as an aid to interpreting pellet counts.

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Received for publication August 24, 1960.

EDITORIAL NOTE

The names of several colleges or universities offering training for fishery biologists and wildlife biologists were inadvertently omitted from the listing of such institutions on pages 195–197 of The Wildlife Society Special Report, "Training and Employment of Wildlife Biologists and Fishery Biologists," Vol. 25(2): 190–199 of this journal. The Editor and The Allen Press will cooperate to correct the oversight by making additions to the type which is being held for reprints.

Another college offering training for wildlife biologists and fishery biologists, and that should have been listed, is:

South Dakota State College (Brookings, South Dakota)

Entomology-Zoology Department

B.S., M.S. (Wildlife Techniques and Conservation); B.S., M.S. (Zoology).

WATER DEPTH AND TURBIDITY IN RELATION TO GROWTH OF SAGO PONDWEED

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Utah Cooperative Wildlife Research Unit, Utah State University, Logan, Utah

The amount of waterfowl food produced by a marsh is often closely associated with the waterfowl carrying capacity of that marsh. A better understanding of the growth of some important waterfowl food plants and a knowledge of their environment are necessary to manage a marsh for optimum propagation of waterfowl food.

This study presents the relationships of water depth and water turbidity to aquatic plant production. This study was not designed to explore the reasons behind the relationships, but rather to show the existence of such relationships.

The author is deeply indebted to the Bear River Club Company, especially William J. O'Connor and John M. Wallace, for financial and material support of this project. Also deserving of thanks are Jessop B. Low and George H. Kelker who reviewed and criticized this manuscript.

Study Area

This investigation was conducted on the marsh of the Bear River Club Company, located on the delta of the Bear River, about 15 mi. west of Brigham City, Utah. The marsh consists of several thousand acres of superb waterfowl habitat. A simple dike system regulates the water depth which reaches a maximum of 2 ft. except in the canals where it may be deeper.

Submersed vegetation consists mainly of sago pondweed (*Potamogeton pectinatus*), horned pondweed (*Zannichellia palustris*), and muskgrass (*Chara* spp.). The emergent vegetation is composed primarily of cattail (*Typha angustifolia* and *T. latifolia*), alkali bulrush (*Scirpus paludosus*), hardstem bulrush (*Scirpus acutus*), and reed grass (*Phragmites communis*).

Soils of the Bear River delta are predominantly clays and sandy clays (Jensen, 1940). Observations indicated soil types and fertility varied somewhat throughout the study area, but no intensive study of soils was incorporated in this investigation.

Methods

Vegetation sampling techniques were similar to those of Rickett (1921, 1924) and Low and Bellrose (1944). A square frame, measuring 12 in. per side, was lowered into the water, and the vegetation confined within it was collected.

Forty-two sampling sites were selected, with the aid of a table of random numbers, from aerial photographs of the western portion of the Bear River Club marsh. The sampling sites were located in water depths ranging from 3 to 20 in. At each site, four vegetation samples were taken systematically. The center of the sampling site was marked with a 4-ft. metal rod. A square foot vegetation sample was taken 4 ft. distant from the rod at each of the four points of the compass. Each of the four samples was placed in a separate container and marked by site number and compass reading.

The amount of vegetation, composed of approximately 95 percent sago pondweed, was determined on a dry-weight basis. Each sample was dried for 48 hr. at 90°C.

At each sampling site, one water sample was collected midway between the water surface and the marsh bottom; i.e., at a sampling site in water 10 in. deep, the water sample was taken 5 in. below the water surface. A Klett-Summerson photoelectric colorimeter with a No. 42 (blue) filter was used to measure the turbidity of the water by determining the amount of light penetration through a given sample of water.

Results

The mean weights of 168 samples of vegetation obtained from 42 sites during the period from July 30 to August 6, 1959 were correlated with water depth (Table 1). The calculated correlation coefficient, $r = 0.80$, is highly significant at the 95-percent level. A maximum sago pondweed production of 152.7 g. was obtained from a sample site in

Table 1.—Mean Weights of 168 Vegetation Samples and Estimated Production from Different Water Depths in 1959

No. of Samples	Water Depth (in.)	Plant Production (mean g. / sampling unit)	Approximate Pounds per Acre
8	3	2.4± 0.7[1]	60
8	3	2.4± 0.7[1]	60
8	5	3.9± 0.7	95
16	6	5.7± 3.9	150
8	7	13.6± 6.2	385
24	8	3.7± 0.9	90
20	10	9.0± 2.8	225
4	11	6.0± 0.5	150
4	12	42.6± 5.1	1,000
8	13	61.7± 9.5	1,500
20	14	75.6± 8.0	1,800
16	15	119.6±14.1	2,850
4	16	117.3± 7.3	2,800
12	18	101.7± .50	2,400
4	19	97.3±15.4	2,350
4	20	113.3±15.6	2,700

[1] Standard error of the mean.

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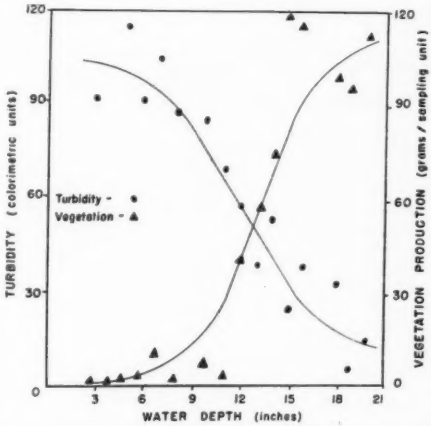

FIG. 1. Relationship between water depth, mean weight of plant mass, and mean turbidity as obtained from 168 aquatic vegetation samples. Vegetation weights and turbidity measurements were stratified as to water depth and then a mean calculated.

water 15 in. deep. The minimum production, 0.2 g., was collected from a sample site in 6 in. of water. Those vegetation samples taken from the same water depths, at gradations of 1 in., were averaged and then plotted (Fig. 1).

A negative correlation exists between water depth and turbidity, deeper water being considerably less turbid than more shallow areas (Fig. 1). The calculated correlation coefficient, $r = -0.91$, is highly significant at the 95-percent level.

The relationship between water turbidity and vegetation production is marked (Fig. 2). A negative correlation, $r = -0.61$, existed between water turbidity and the amount of aquatic vegetation present. This correlation coefficient is highly significant at the 95-percent level. The weights of vegetation samples collected from water with the same turbidity level, within 10 colorimetric units, were combined and averaged (Table 2) and then plotted (Fig. 1). The greatest mass of aquatic vegetation, 152.7 g., was collected from a sample site in water with a small amount of suspended matter present. The lowest production of vegetation, 0.2 g., was found in water with a large amount of suspended matter present.

DISCUSSION AND CONCLUSIONS

A complex relationship exists between vegetation production, water depth, and water turbidity. A cause-and-effect relationship undoubtedly exists between these variables; however, the identity or degree of the cause and effect was not determined in this study.

Turbidity and plant production were closely associated. This study shows a relationship between turbidity and the amount of aquatic vegetation present, a relationship stronger in the 6- to 18-in. depth than in the shallower or deeper areas. Other observers have suggested a relationship between vegetation production and water turbidity (Martin and Uhler, 1939; Low and Bellrose, 1944; Chamberlain, 1948; Nelson, 1954). Chamberlain (1948), reporting on a study conducted on the Back Bay National Wildlife Refuge in Virginia, states: "Turbidity, however, was found to be correlated with the quantity of aquatic growth, the better areas being less turbid." He found that turbidity was the chief limiting factor in aquatic plant growth. However, the report did not include statistically sound quantitative studies to determine the extent of this relationship.

I also found water depth to be closely associated with aquatic plant production; the most striking relationship was in the water depth zone of 9 to 15 in. Other observations have also shown a relationship between water depth and aquatic plant mass (Martin and Uhler, 1939; Low and Bellrose, 1944; Hall, *et al.*, 1946; Singleton, 1951; Anonymous, 1958). However, again as with turbidity relationships, no intensive study was conducted to show the extent of this relationship.

In shallow water the amount of submersed vegetation is low and the turbidity is high. Where water depth exceeds 6 in., turbidity decreases rapidly, but vegetation production increases abrupt-

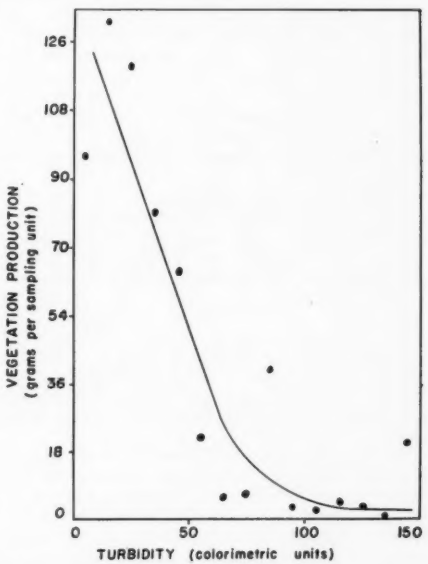

FIG. 2. Relationship between water turbidity and the mean weights of vegetation samples collected at 42 sampling sites. Vegetation samples were stratified into turbidity classes and a mean weight calculated.

TABLE 2.—MEAN WEIGHTS OF 168 VEGETATION SAMPLES AND ESTIMATED PRODUCTION FROM WATER OF DIFFERENT TURBIDITIES IN 1959

Relative Turbidity Rating	No. of Samples	Water Turbidity[1]	Plant Production (mean g. / sampling unit)	Approximate Pounds per Acre	Mean Pounds per Acre
Low	4	0– 10	97.3± 4.0[2]	2,350	2,050
	8	11– 20	133.0±14.1	3,200	
	8	21– 30	120.8±11.3	2,800	
	24	31– 40	81.5±20.8	1,950	
	24	41– 50	65.7±16.9	1,500	
Medium	8	51– 60	22.1±14.1	550	400
	4	61– 70	6.6± 1.7	150	
	16	71– 80	7.1± 3.3	175	
	16	81– 90	39.9±18.2	950	
	20	91–100	4.3± 1.9	100	
High	12	101–110	2.3± 1.5	55	125
	8	111–120	5.2± 1.4	125	
	4	121–130	4.6± 0.7	100	
	4	131–140	0.2± 0.2	5	
	4	141–150	20.7± 9.9	500	

[1] Units on a Klett-Summerson photoelectric colorimeter.
[2] Standard error of the mean.

ly as water depth exceeds 9 in. It seems therefore that by inundating the majority of the Bear River Club marsh or similar western marshes to a depth exceeding 9 in. the greatest amount of submersed waterfowl food could be produced (if all other factors remained constant). Since no sample was collected from water more than 20 in. deep, management information cannot be projected to the deeper waters. It is suspected, however, that water depth–vegetation relationships will remain until there is reached a water depth through which light rays can no longer pass in quantity or a depth which exceeds the optimum requirements of the plant in question.

Water depth and turbidity are not the only factors that affect growth and production of waterfowl food plants. Soil type, soil fertility, water chemistry, wave action, and countless other factors play important roles in determining plant growth.

SUMMARY

To better understand the complex ecological relationships within waterfowl marshes, a vegetation production study was initiated in the Bear River marshes during the summer of 1959. Vegetation and water samples were collected from 42 sampling sites.

Strong correlations were found between vegetation production and water depth, water depth and turbidity, and turbidity and vegetation production. Deeper waters were observed to support larger crops of aquatic vegetation. These deeper waters also contained less suspended matter.

Water depth at the delta of the Bear River is a significant factor to be considered in the management of the local marshes for the production of the greatest amount of aquatic waterfowl food.

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NOTES ON WING MOLT IN THE YEARLING WILD TURKEY

Lovett E. Williams, Jr.

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After examining a large number of specimens representing all races, Petrides (1942) concluded that retention of primaries 9 and 10 from the juvenile plumage into the first post-juvenile plumage (first-winter plumage) is a species-wide phenomenon in the wild turkey (*Meleagris gallopavo* Linnaeus). Later, in describing first-winter plumages in the Galliformes, Petrides (1945), somewhat reversing his earlier opinion, reported a tendency for Florida turkeys (*Meleagris gallopavo osceola* Scott) to retain only the 10th juvenile primary in winter. His latter finding has been repeatedly overlooked by subsequent writers.

Distal primaries.—I have examined 37 juvenile specimens from the southeastern United States: 12 from northern Florida, 17 from Alabama, 4 from Mississippi, 3 from southern Georgia, and 1 from Louisiana. With only four exceptions, these specimens, taken in all seasons, retained only the 10th primary from the juvenile plumage. The ninth had been replaced with a feather similar to number eight. (The exceptions: one spring and one fall juvenile had replaced both distal juvenile primaries; one winter and one summer (second-year) juvenile were retaining both distal juvenile primaries 9 and 10.) Supplementing these data is the testimony of biologists in Florida (James A. Powell, pers. comm.) and Mississippi (S. G. Clawson, pers. comm.) that turkeys in their respective states do not retain juvenile primary nine as part of their first-winter plumage. It seems clear, then, that turkeys in the Gulf States, including those of Florida and nearby southern Georgia westward at least to the Mississippi River, do not normally hold juvenile primaries 9 and 10 through the winter. The exact geographic extent northward and westward is not readily apparent.

Thirty of the 37 specimens examined by the writer came from the coastal plain of the Gulf of Mexico. Clawson (pers. comm.) reports that Mississippi turkeys from well into the northern part of the state (Greenville) exhibit a single juvenile primary during winter, but he can offer no definite information about populations north and northeast

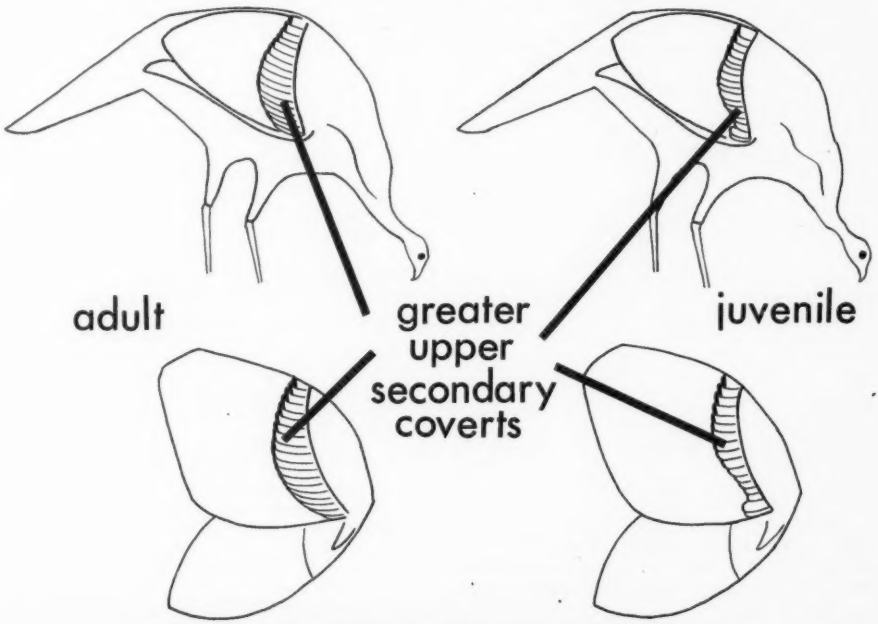

FIG. 1. Greater upper secondary covert configuration in juvenile and adult turkeys.

of Greenville. I have one specimen from northern Alabama which has the two juvenile primaries and is thus typical of *silvestris* as described by Bent (1932), Petrides (1942), Leopold (1943 and 1944), and others. No data from northern Georgia and South Carolina are at hand. Turkeys throughout Florida retain only the most distal juvenile primary during winter. Wherever the boundary between the two conditions lies, it should be expected to take the form of a zone in which both conditions occur.

In view of the molting habits of the turkey in the Southeast, Leopold's (1943) inference, that replacement of juvenile primary 9 during the first post-juvenile molt is indicative of genetic contamination by domestic strains, cannot be applied to the species throughout its range. This fact does not, however, preclude the possible validity of the hypothesis outside the Gulf States.

Greater upper secondary coverts.—A noticeable difference exists between juvenile and adult turkeys in the appearance of their greater upper secondary coverts (Fig. 1). The covert patch can be used in the field to distinguish juveniles from older turkeys and should be especially useful with hens, since they do not exhibit other readily observable age characters.

The greater upper secondary coverts of the first-winter plumage (first post-juvenile plumage) are acquired during the first post-juvenile molt in midsummer. Juvenile coverts are dropped and replaced beginning with covert number 3 and proceeding proximally. The molt consumes several weeks during which the young turkey grows rapidly. As the bird grows during the molt, each new covert is larger, darker, and more glossy than the preceding. Long after the molt has been under way, coverts two and one are dropped, in that order. These late-coming coverts of the first-winter plumage become as large as covert 12 and distinctly larger and darker than adjacent coverts 3 through 7. This molt has been described by Leopold (1943).

Fig. 1 illustrates the gross aspect of the covert patch as exhibited by spring hens, adult and juvenile. Three distinctive features of the covert patch should be pointed out: (1) juvenile coverts become increasingly shorter, browner, and less glossy distally (except the most distal two); those of the adult are uniformly dark and glossy and as a group present a more graceful and symmetrical outline in profile; (2) the two most distal coverts of the juvenile are much longer, darker, and more glossy than adjacent coverts; and (3) in the adult coverts are longer, giving the covert patch a greater anteroposterior depth. The young turkey retains its distinctive greater upper secondary coverts until they are replaced during the post-nuptial molt of late summer in the individual's second year.

Under most field conditions, careful scrutiny with the aid of optical equipment may be necessary in order to distinguish young hens by this method.

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COLLECTING LOUSEFLIES FROM MOURNING DOVES[1]

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Records of the collection of louseflies from mourning doves are few. Bequaert (1939) reported *Microlynchia pusilla*, Coatney (1938) collected *Stilbometopa podopystyla* (= *S. podopostyla*), Herman (1937) collected *Ornithoica confluenta*, Brennan (1938) reported *S. podopostyla* and *M. pusilla*, and McClure (1943) reported *M. pusilla*. The number of flies collected was small. Brennan, however, reported the lousefly as abundant in a collection of two or three dozen mourning doves, with 10 flies as the maximum individual infestation.

We would like to express appreciation to Joseph C. Bequaert, Department of Entomology, University of Arizona, Tucson, Arizona, for assistance in the identification of hippoboscid flies and to B. F. Overton, 2306 Arcady, Garland, Texas, for assistance in the collection of mourning doves.

METHODS

Twenty-three mourning doves (*Zenaidura macroura*) were collected by shooting from May 7 to July 30, 1960, in Denton County, 4 miles west of

[1] This study was supported in part by the National Science Foundation.

TABLE 1.—NUMBER AND IDENTIFICATION OF HIPPOBOSCID FLIES COLLECTED FROM MOURNING DOVES IN DENTON COUNTY, TEXAS

Date	Number of Doves Examined	Flies Collected	Flies Lost	Number of Hosts	Species
September 1, 1960	31	4	1	4	*M. pusilla*, 4♂
September 2, 1960	33	0	1	1	
September 5, 1960	14	3	1	2	*M. pusilla*, ♂ and ♀
					S. podopostyla, ♀
September 8, 1960	15	5	0	3	*M. pusilla*, 4 ♂ and 1 ♀
September 11, 1960	11	2	0	2	*M. pusilla*, ♂ and ♀
September 17, 1960	2	2	0	1	*S. podopostyla*, ♂ and ♀

Celina, Texas. Many methods were used in an attempt to capture the elusive hippoboscid. Some of the methods involved 1) placing the bird in a clear plastic bag, 2) spraying the bird with insecticide while the bird was in a paper bag, 3) dusting the bird with pyrethrum, 4) placing the bird in a screenwire cage 12 × 12 × 18 in., 5) ruffling the feathers of the bird in the inclosure of a car, 6) covering the bird with a light-proof cardboard box that was fitted with a quart, clear-glass jar, and 7) covering the bird with an insect net. None of the methods were efficient.

On September 1, 1960, when the main collection of mourning doves began in the same locality, a new and successful method for collecting louseflies was developed. The method, similar to that of S. M. Russell (Bequaert, 1957), involves the use of a widemouthed gallon jar and a small piece of cloth.

A mourning dove downed by shooting was approached rapidly in such a way that no shadow fell on the bird. During the last 5 ft. of the approach, a downward, sweeping motion was made with the jar in a position so that the bird could be quickly covered and the mouth of the jar pressed firmly into the soil. The cloth was then worked over the mouth of the jar. When the jar was shaken, flies present left the host. If flies were not seen flying in the jar, the feathers of the bird were ruffled by a hand inserted into the jar through a narrow opening between cloth and jar. Flies have been observed leaving the host during muscular spasms of the dying bird; touching the bird will often induce these muscular spasms. A live bird was killed in the jar by bloodless separation of cranium and cervical vertebrae. The dove was removed by allowing it to drop from the inverted jar. The jar was then placed upright and the cloth drawn firmly across the mouth. Alcohol (70 percent) was poured upon the cloth and allowed to drip into the jar. Dead flies were stored in 70 percent alcohol.

RESULTS

Nineteen hippoboscid flies were collected from 13 of 106 mourning doves examined. Thirteen of the flies were *Microlynchia pusilla* and 3 were *Stilbometopa podopostyla*. Three flies were lost because of faulty manipulation (Table 1).

DISCUSSION

Failure to collect louseflies from doves successfully in the spring was due either to an improper method of collection or an absence of flies on the host. We prefer the former explanation since several of the more likely collection methods used in the spring failed to be successful in the fall when flies were known to be present.

The fact that hippoboscids are captured from one dove but not another poses a problem, the answer to which is not readily apparent. Time lapse, distance, the jolting impact of the dead bird striking the ground as compared to the gentle settling of the wounded bird, and attempts to capture flies from birds dead on the ground as compared to attempts made upon birds alive on the ground indicate that a firm line cannot be drawn for maximum capture of flies. Flies have been captured under unlikely circumstances. For example, a dove that was shot high in the air, at a distance of 60 yd., fell dead at a distance of 130 yd., required 5 min. to locate, yet yielded two flies. All factors considered, the dove shot at short distance with a rapid fly-capture attempt should yield the most flies. Concerning the capturing of flies, we are in agreement with O'Roke (1932) whose work on the lousefly of California valley quail indicated that flies will escape unless the bird was inclosed in a fly-proof container within seconds after the bird was killed. We believe, also, that the captured flies are those in the process of feeding. Our belief is based upon variation in the success of capturing flies and the fresh-filled appearance of belated-captured flies as opposed to the partially filled appearance of the flies captured immediately.

No attempt is made to evaluate hippoboscid infestation quantitatively since the number of flies captured is greatly influenced by collection circumstances and experience of the collector.

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HUNTING SEASON WEIGHTS OF NEW MEXICO WILD TURKEYS[1]

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During the hunting season of September 24–26, 1960, weights were obtained from 90 wild turkeys (*Meleagris gallopavo merriami*) taken in northwestern New Mexico. Weights of 16 additional turkeys were collected from November hunts in southwestern New Mexico. These weights are presented for their intrinsic value, since there is a dearth of such data in published form. Additional unpublished data are presented on 414 wild turkey weights from the 1951–54 hunting seasons in New Mexico, obtained from Federal Aid Job Completion Reports. Comparisons are made between turkey weights in September and November and with data on 149 turkey weights taken in Arizona (Russo, 1958).

Sex, age, and weight data were collected from each turkey checked. Sex determination was made on the basis of black- or white-tipped central breast feathers (white in females) after Burget (1957). Age determinations were based on the 9th and 10th primaries, which are unbarred in juveniles, barred but pointed in yearlings, and barred and rounded in adults (Burget, 1957). As the distinction is relative, there may be some error in distinguishing between adults and yearlings. Subsequent reference to weights indicated that any such error was probably limited to females, where a weight overlap existed. Weights were taken to the nearest one-quarter pound on household platform scales. In six instances the proper breast feathers were missing from juvenile birds, and these were classified as unsexed juveniles.

Of the 90 turkey weights from September, 17 were of whole turkeys, and 73 were of eviscerated birds. Seven of the former were subsequently eviscerated and reweighed. Both whole and eviscerated weights were obtained from six additional turkeys taken in November. In the interest of presenting comparable data, an attempt was made to determine the approximate proportional difference between whole and eviscerated turkeys. Whole and eviscerated weights of these 13 turkeys are presented in Table 1. The percent difference was

[1] A contribution of New Mexico Federal Aid Project W-97-R, Wild Turkey-Predator Relationships.

TABLE 1.—DIFFERENCE IN WEIGHTS OF WILD TURKEYS, WHOLE AND EVISCERATED (in pounds)

Age	Sex	Whole	Eviscerated	Difference	Percent Difference
Adult	F	7.62	7.00	0.62	8
Adult	F	7.00	6.50	0.50	7
Yearling	M	18.50	16.00	2.50	14
Yearling	F	9.50	8.25	1.25	15
Yearling	F	8.44	7.50	0.94	11
Yearling	F	7.25	6.12	1.13	16
Juvenile	M	12.50	10.50	2.00	16
Juvenile	M	12.00	10.50	1.50	12
Juvenile	M	12.00	10.50	1.50	12
Juvenile	M	7.75	6.50	1.25	16
Juvenile	M	7.50	6.50	1.00	13
Juvenile	M	4.94	4.16	0.78	16
Juvenile	F	7.75	6.50	1.25	16
Mean					13

TABLE 2.—WEIGHTS OF EVISCERATED TURKEYS TAKEN SEPTEMBER 24–26, 1960 (in pounds)

Age	Sex	Mean Weight	Number	Std. Dev.	Range
Adult	M	14.90	10	1.70	12.25 to 17.00
Yearling	M	9.31	3	2.25	6.75 to 10.99
Juvenile	M	5.78	19	1.17	4.00 to 7.50
Adult	F	8.85	10	1.97	6.50 to 13.00
Yearling	F	7.22	16	1.17	4.25 to 9.25
Juvenile	F	5.18	26	1.66	2.25 to 9.50
Juvenile	?	4.93	6	1.10	4.00 to 7.00
Adult and yearling	M	13.61	13	3.00	6.75 to 17.00
Adult and yearling	F	7.86	26	1.69	4.25 to 13.00
All juveniles		5.38	51	1.45	2.25 to 9.50
All males		8.96	32	4.31	4.00 to 17.00
All females		6.52	52	2.14	2.25 to 13.00
All classes		7.29	90	3.35	2.25 to 17.00

calculated for each bird, and the mean was used to convert the 10 whole weights to eviscerated weight. These converted weights are included in Table 2.

The percent difference between whole and eviscerated weight does not appear to vary directly with total weight or age, a calculated regression for both factors proving to be non-significant. Thus this factor should be applicable to turkeys of all weights and ages. Its accuracy is limited by variations in crop contents, but it does provide a useful means of equating weights collected during hunting seasons.

The age of four of the turkeys listed in Table 1 may be questioned. The bird weighing 16 lb. eviscerated, called a yearling, and the 3 male birds weighing 10.5 lb. eviscerated, called juveniles, all fall outside the normal weight range for their respective age classes. They were taken in November 1960, and possessed all of the characteristics of the indicated age class. The yearling bird was in exceptionally good condition, with a large amount of visceral fat.

Weights of turkeys taken during the November 1960 hunt in southwestern New Mexico are given in Table 3. Although the sample was small, all of the sex and age classes were heavier in November than in September. A greater difference existed between juvenile male than juvenile female weights, as would be expected.

TABLE 3.—WEIGHTS OF EVISCERATED TURKEYS TAKEN NOV. 12–27, 1960 (in pounds)

Age	Sex	Mean Weight	Number	Range
Adult	M	15.66	1	–
Yearling	M	15.75	2	15.50 to 16.00
Juvenile	M	8.43	7	4.75 to 10.50
Yearling	F	8.25	1	–
Juvenile	F	5.55	5	4.00 to 6.50
Adult and yearling	M	15.72	3	15.50 to 16.00
Adult and yearling	F	8.25	1	–
All juveniles		7.23	12	4.00 to 10.50
All males		10.62	10	4.75 to 16.00
All females		6.00	6	4.00 to 8.25
All classes		8.88	16	4.00 to 16.00

Table 4 is a summary of turkey weights from November hunting seasons in the Santa Fe National Forest, Pecos Division, 1953–54 (Lang, 1954 and 1955); in the Lincoln National Forest, Sacramento Division, 1954 (Lang, 1955); and the Gila National Forest, 1951–53 (Gordon and McClellan, 1954). The detail of these additional data varies considerably. Some birds were sexed only, some were aged only, no adult-yearling distinctions were made, and in general only mean weights were provided. The smallest turkey included in Table 4 was a juvenile female weighing 4 lb., and the largest was an adult male weighing 28 lb. The latter was taken in the Sacramento Mountains, and was weighed at a Game Department checking station.

With the exception of adult and yearling males, turkeys taken in November in 1951–54 averaged slightly heavier than those taken in November 1960. The small sample size in 1960 is sufficient to explain this difference. Juveniles taken in September averaged 2.01 lb. lighter than those taken

TABLE 4.—WEIGHTS OF EVISCERATED WILD TURKEYS TAKEN IN NOVEMBER SEASONS IN THE SANTA FE, LINCOLN, AND GILA NATIONAL FORESTS, 1951–54 (in pounds)

Age	Sex	Mean Weight	Number
Adult[1]	M	14.37	68
Juvenile	M	8.56	66
Adult[1]	F	9.72	95
Juvenile	F	6.74	118
All juveniles		7.39	184
All males		11.70	149
All females		7.79	258
All classes		9.24	414

[1] Includes yearlings.

in November. Adult and yearling males averaged 0.76 lb. heavier in November than in September, and adult and yearling females averaged 1.86 lb. heavier. This would indicate that turkeys one or more years old attain their greatest weight immediately prior to the winter period.

Russo (1958) reported on weights of 149 Merriam's turkeys taken during 1956 and 1957 in early October hunts in northern Arizona. Forty-nine of these weights were from whole turkeys, 61 from eviscerated, and 39 from dressed birds. The average weight of 24 eviscerated adult and yearling males was 10.15 lb., of 24 adult and yearling females, 6.75 lb., and of 13 poults (male and female), 4.23 lb. The average whole weight of 21 males was 15.04 lb., of 18 females, 7.58 lb., and of 10 poults, 4.88 lb. Application of the formula calculated in Table 1 shows that eviscerated weights of the whole birds are 13.08 lb. for males, 6.59 lb. for females, and 4.24 lb. for poults. With the exception of the adult and yearling males, for which weights ranged from 7 to 17.75 lb., the calculated figures are remarkably close to the average of the eviscerated birds. This additional evidence, taken from another state and calculated in a different manner, indicates that the 13 percent figure (Table 1) for equating whole and eviscerated weights is sufficiently accurate for field use.

Converting the 49 whole weights to eviscerated weights shows that adult and yearling males averaged 11.52 lb., 42 adult and yearling females averaged 6.68 lb., and 23 poults averaged 4.23 lb. Turkeys taken in New Mexico in September 1960 averaged nearly 1.5 lb. heavier than those taken in Arizona during comparable hunting seasons. No reason is suggested for this difference.

SUMMARY

Weights of 106 Merriam's turkeys killed in September and November 1960 in New Mexico are compared with weights of 414 turkeys killed earlier in New Mexico, and with weights of 149 Merriam's turkeys from Arizona. A conversion factor (13 percent) for equating weights of eviscerated turkeys was calculated.

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BOOK REVIEWS

The Kirtland's Warbler. By Harold Mayfield. Bulletin 40, Cranbrook Institute of Science, Bloomfield Hills, Michigan. 1960. xv + 242pp. $6.00.

The author of *The Kirtland's Warbler* is Director of Personnel Relations for Owens-Illinois, Toledo, Ohio—his sole claim to amateur standing as a student of birds. A Fellow of the American Ornithologists' Union, he served as its secretary 1953–1958, and is now president of the Wilson Ornithological Society.

In 1944 he visited the nesting grounds of the Kirtland's warbler with Josselyn Van Tyne, Curator of Birds at the University of Michigan Museum of Zoology, whose own careful study of the species began in 1930. Upon Van Tyne's death in 1957, his records were given to Mayfield, who had worked closely with him.

The Kirtland's warbler (*Dendroica kirtlandii*) is a songbird of exceptional ecological interest. A cooperative survey, conducted by Mayfield in 1951, revealed that the entire breeding population of this distinct species numbered less than 1,000 individuals. The first discovery of its nesting was in 1903, and no nests have been found anywhere outside 12 counties of northern Lower Michigan. Its ecological niche is an extremely narrow "life form" where the interlacing branches of a coniferous thicket are in contact with very porous sandy soil, in the presence of sparse ground cover. The jack pine plains of the area provide such a habitat. *Pinus banksiana* requires fire to open its cones and is adapted for growth on the repeatedly burned-over sandy plains. Kirtland's warbler is often called the jack pine warbler, although in recent years it has been known to nest among planted red pines (*P. resinosa*). Since nests are in depressions on the ground, any but highly permeable soil would be disastrous in a rainstorm.

Mayfield considers Kirtland's warbler to be a relict species, the range of which has contracted with the withdrawal of glacial ice and the northward shift of the range of the jack pine. At present the warbler's breeding is limited to an area of relatively flat country, where fires were formerly unimpeded in their sweep across large expanses. In recent years the efficient supression of forest

fires has permitted trees on much of the warbler's range to grow beyond the suitable stage. Although not an immediate threat to the species, shrinking of habitat looms as a possible ultimate cause of extinction.

In 1957, at the suggestion of Mayfield and other ornithologists, the Michigan Conservation Commission authorized the designation of three areas of state forest to be managed for the benefit of Kirtland's warbler. More recently the U.S. Forest Service, which administers much of the land in the warbler's range, has taken first steps to establish management areas for the species. Clear-cutting in short rotation, prescribed burning, and strip or clump planting of conifers are possible management methods.

The brown-headed cowbird (*Molothrus ater*) is a dangerous enemy of the Kirtland's warbler. Mayfield believes it to be a relative newcomer in the Kirtland's range—a follower of the settler's plow and cow. In a series of carefully analyzed tables, based on many hours of nest study by a number of observers, Mayfield shows the profound effect of cowbird parasitism on the delicately balanced life-equation of *Dendroica kirtlandii*.

Reading *The Kirtland's Warbler*, the wildlife manager accustomed to concentrating on his own particular problems can resume wide-screen viewing of the ecological picture. Mayfield's book is an example of what a contribution to knowledge should be. We expect an author to present the known facts with a prudent observance of statistical procedure, and to draw inferences that give us a comprehensive understanding of interrelationships. When he does this in friendly, direct language, avoiding both jargon and contrivance, we have been very well treated indeed. Mayfield has given us extra dividends in a bibliography of 458 titles and a brief statement of problems for future study. The print is clear, the layout pleasing. A color plate of a Kirtland's warbler family by Roger Tory Peterson serves as cover picture and frontispiece.

By the time this review has been published Mayfield will have conducted a second comprehensive census of the total population of Kirtland's warbler, 10 years after the first such effort. Some fear that the count will be down significantly. It is only too likely that Mayfield's book will stand as the final and definitive story of the species. To my knowledge, no other threatened species has been so thoroughly studied by so many competent observers, or been more fortunate in its biographer. —DONALD W. DOUGLASS, Game Division, Department of Conservation, Lansing 26, Michigan.

Ecology of the Aspen Parkland of Western Canada in Relation to Land Use. Edited by R. D. Bird, Res. Branch Can. Dept. Agric., Ottawa, Pub. 1066. 1961. 155pp.

This is a well-documented description of past vegetation and animal life upon which changes were induced by land-use practices of the white man. General, nonstatistical descriptions of grassland, forest, and aquatic communities are given. The influence of Indian fires in restricting distribution of aspen forest is firmly established, but the evidence seems insufficient to conclude that bison and wapiti overutilized the arboreal vegetation to the point of limiting distribution. Aspen forests initially expanded over former grassland when the white man controlled fires. The trend now is toward intensified agriculture, reduction in aspen forest, and simplification of communities through the use of pesticides. Valuable comments are provided on general changes in many populations of insects, birds, and mammals. The description of biotic changes provides a useful background for understanding present plant and animal life in the region considered.—H. K. BUECHNER, Department of Zoology, Washington State University, Pullman, Washington.

The Fern Guide. By Edgar T. Wherry. Doubleday Nature Guides Series. Doubleday and Company, Inc. Garden City, N.Y. 1961. 318pp., illus. $3.95.

In many ways the ferns are a gratifying group of plants to study. The number of species, in temperate regions, is not overwhelming, so that a normal mortal can gain a good command of them; they are diversified enough to arouse interest, and the problems of identification are sufficiently involved to offer a challenge.

The present volume is devoted to the species—some 135 in number—which occur in "northeastern and midland" United States and adjacent Canada. To many of these species a page of text and one of illustrations are devoted, to others half a page of each. At the top of each page of text the colloquial name of the species is given; this is followed by a careful description, including, in some cases, notes on the cytology; then the range, habitat, and culture of the species are outlined. The scientific name and synonyms are listed, and further notes and explanations are added. Identification is facilitated by keys to the families, genera, and species.

The illustrations, by James C. W. Chen, consist of careful and effective line drawings of plants, and helpful enlargements of pinnae, sori, and indusia.

All of this material is meticulously prepared and well presented, so that identification of the better defined species should be relatively easy, even for those who are not specialists. If difficulty is experienced in the determination of certain species, it may not be the user's fault. In the genus *Dryopteris*, for instance, the author lists 20 hybrids, many showing intergradations between the parents. Plants do not necessarily conform to man-made categories.

The value of this volume is further enhanced by a good "Glossary of Technical Terms," a brief chapter on "Fern Cytology"—some will wish it were longer—and separate disquisitions on "Fern Spores,"

"Exploring for Ferns," "Ferns in the Garden," and a page listing "Recent Fern Literature." The book concludes with a helpful list of the "Authors of Fern Names," giving their dates and nationalities, an alphabetical index of the "Significance of Epithets of Species and Lesser Taxa," and separate indexes to technical and to colloquial names.

Since by tradition a reviewer is not only permitted but expected to give some unpleasant evidence of his good faith, it is not correct to say (p. 25), "A tetraploid sperm may fuse with a diploid egg (or vice versa), whereupon a triploid should result;" Fernald's first name (p. 35) was not Myron. The term Lycosphen (p. 37), while obviously used for convenience, is not coordinate with Fern, as the author is undoubtedly aware, and some at least will consider it unfortunate and scientifically indigestible. The sequence of presentation of the major groups, as the author states, is in general the reverse of their evolutionary development; and many—even many amateurs—would find the use of the volume facilitated if the accepted scientific name, which the author has obviously checked with care, were given, in addition to the colloquial names, at the top of the page of text and also below the illustrations.

But these are trivalities. This is, after all, a guide to the ferns; it is a good one, and one which should serve to make this group of modest plants far more accessible to those still interested in contemplating some of the finer aspects of life on this earth.—EDWIN B. MATZKE, Department of Botany, Columbia University, New York City.

Nematology. Edited by J. N. Sasser and W. R. Jenkins. The University of North Carolina Press, Chapel Hill. 1960. x + 480pp. $12.50.

The book "Nematology" contains a series of lectures presented during the Southern Regional Graduate Summer Session in Nematology in 1959. A total of 18 authors, representing many of the world's leading authorities on nematodes, have contributed. Eight subject areas are covered—methodology, morphology and anatomy, special treatment of selected nematode groups (taxonomy), physiology and biochemistry, genetics and cytology, nematode ecology, host-parasite relations, and nematode control. Special emphasis has been given to plant parasitic and soil-inhabiting nematodes. In certain chapters reference is also made to animal parasitic, aquatic, and marine forms.

In the preface the editors have stated that this lecture series was put into book form to serve as a reference for teachers and research workers, and as a text for advance courses in nematology. Therefore, my comments will be restricted to its usefulness in fulfilling these purposes.

When used as a reference source, "Nematology" offers much information to the teacher and research worker. It is in this area that I feel the book is most valuable. The discussions, excepting those on taxonomy and chemical control of nematodes, are very thorough and bring up to date most of the available literature. Reference is given to many recent techniques which have been or could be useful in studying the physiology and biochemistry, genetics and cytology, host-parasite relationships, and methods for biological control of nematodes. Many of the techniques discussed, for example, those dealing with physiology and biochemistry, have been found useful in studying organisms other than nematodes. However, such techniques would likely be beneficial in nematode research in that they probably could be refined and adapted to use in studying plant parasitic and soil-inhabiting nematodes.

The bibliographies are excellent for the most part. It seems odd, however, that in the chapter entitled "Methods in Nematology: A Review" eight pages of references were listed without giving a single title. This has made one of the most complete and valuable bibliographies cumbersome and difficult to use.

In my opinion the use of this book as a text would be limited since there appears to be no clear, concise unity or pattern of presentation. The composite nature of the book is undoubtedly responsible for part of this difficulty. It seems obvious that most of the discussions given were not designed to be incorporated into a book; hence there is a lack of balance in the relative importance given to and within certain subject areas. For example, the areas of taxonomy and control, probably the most advanced areas in the science of nematology, were covered in 58 and 32 pages respectively, whereas 85 pages were given to a discussion of physiology and biochemistry where relatively little is known about nematodes. Furthermore, much of the physiology and biochemistry discussion dealt with organisms other than nematodes and most certainly with organisms other than the plant parasitic and soil forms which were supposedly emphasized. It is true that the physiology and biochemistry of nematodes are of great importance and that relatively little is known about them; however, long discussions which are not to the point would probably tend to confuse and bewilder the student rather than to stimulate him.

The section concerned with taxonomy was so reduced as to be sketchy and again there was a lack of constancy and balance. The selected nematode groups contained anywhere from a single genus to entire superfamilies. Four pages were used to discuss two taxonomic characters of the genus *Heterodera*, whereas only 3 pages were given to discussions of the entire superfamilies Aphlenchoidea and Dorylaimoidea. More useful information would have been presented had the system used for covering the subfamily Hoplolaiminae by Perry or the family Criconematidae by Oostenbrink been followed throughout this section. These writers included in their remarks discussions of history and taxonomic status of their groups and also included

workable keys to the species involved. Such treatment was clear, concise, and to the point.

The section on morphology was well handled. Adequate space was given to this section and there appeared to be no overemphasis of any one subject. The drawings included by Hirshman, illustrating morphology of nematodes, should be very useful to students of nematology.

Nematode ecology was reviewed by Winslow. His treatment of plant parasitic forms was thorough and should be of interest to both nematologists and students. In certain areas, however, he intermingled facts with opinion and this may lead to some confusion. For example, he states that those nematodes which feed on both fungi and higher plants are truly facultative parasites. This infers that such nematodes feed primarily on non-living organic matter or that fungi are not living organisms.

The discussions on nematode control were generally good. Perhaps the only subject in this section which did not receive adequate treatment was the discussion of chemical control of nematodes. Oddly enough, it is in this area that control studies have been concentrated in recent years. In my opinion, a discussion such as that presented during the course by Cleve A. I. Goring on theory of soil fumigation would have strengthened this section of the book.

In conclusion, it is only fair to say that there has been great need for a text in the science of nematology. The book "Nematology" represents a definite contribution although it does not completely fulfill this purpose.—L. R. FAULKNER, Irrigation Experiment Station, Washington State University, Prosser, Washington.

Wildstandsbewertschaftung und Wildschadenverhütung beim Rotwild (Wildlife Management and Damage Prevention for the Red Deer). By Erhard Ueckermann. Verlag Paul Parey, Hamburg and Berlin. 1960. 162pp., 90 illustrations. 12.40 Deutschmarks ($5.00).

The author completed his requirements for the Ph.D. from the University of Göttingen (West Germany) in 1951, with a study of the management of the fallow deer (*Dama dama*) in relation to forested land. In 1957 he became director of the newly established state Forschungsstelle für Jagdkunde und Wildschadenverhütung (Research Center for Hunting Science and Prevention of Game Damage) at Beuel-Niederholtorf, West Germany. This research center carries on investigations dealing with all sorts of wildlife problems, but the interests of the director are focused mainly on big game. In 1957 his book on wildlife management and damage prevention for the roe deer (*Capreolus capreolus*) appeared. The present volume, employing the same approach, deals with the red deer (*Cervus elaphus*).

This book contains the following chapters: Distribution; Habits, Development, and Genetic Strains; Management of the Stock: Damage; Measures for the Prevention of Damage; Conclusions. The author, like modern German wildlife scientists generally, has two principal aims: to produce the maximum number of trophy heads per unit area per year; and to accomplish this with a minimum of damage to trees and crops. The stripping of bark from trees is the principal damage caused by red deer, although they also browse forest reproduction and occasionally cause field damage. In the course of his treatment of management of the stock the author develops two concepts of proper animal density: stocking compatible with the well-being of the habitat; and stocking compatible with the well-being of the deer. The latter is, of course, higher than the former. Past concern mainly for the quality of the game, and neglect of the quality of the habitat, has led to the extensive forest damage that the author is now attempting to relieve. He finds a measure of successful compromise in adjusting stocking to habitat quality, supplemental feeding (including both direct feeding and food patches) and the use of repellents and protective devices, all of which are treated in detail in this volume. Except for adjusting stocking to habitat, these measures are expensive, and adapted mainly to situations requiring intensive management. The investigations of habitat quality are equally intensive, but the results are of broader application.

Assuming that the main part of the range of a herd of red deer is a forest, the author scores this forest quantitatively with relation to amount of cultivated land bordering it; amount of meadow bordering it; species of trees; and parent material of soil. For example, a forest containing over 50 percent Norway spruce receives only 10 points, while one containing over 60 percent oak receives 25, and a parent material of sand receives only 14, while one of limestone receives 35.

From a study of 53 reviers, or red deer forests, the author has determined the general relationships between habitat quality, deer density, and barking damage, both with and without feeding. Selecting a stocking of 2.0 deer (in winter) per 100 hectares, we see from his data that barking damage on the poorest habitat is eight times that on the best habitat. If only a low level of barking damage is to be tolerated and no supplemental feeding is practiced (to simulate North American conditions); then permissible deer densities per 100 hectares are fair habitat—0.5 and good habitat—3.0. In terms of winter biomass, these stocking values amount to 250 pounds and 1,500 pounds of living deer per square mile respectively.

Supplemental feeding, in good habitat, will raise the carrying capacity about 33 percent (from 3.0 to 4.0 deer per 100 hectares). Greater increases in deer density result in increased forest damage. Much of this book deals with methods (and costs) of protecting the trees from this damage so that a still higher level of deer stocking can be tolerated.

The questions dealt with in such an able and detailed manner by the author are not so remote from North American experience as might at first appear. Like the German forest managers, we have tolerated a large measure of forest damage for the sake of a heavy stocking of game. Now, like Dr. Ueckermann, we are seeking to reconcile the deer to rational forest management. As a clear demonstration of the cost of violating the limits imposed by the habitat, his work is of great value to us.—RICHARD D. TABER, School of Forestry, Montana State University, Missoula.

A Gathering of Shorebirds. By Henry Marion Hall. Edited by Roland C. Clements. Devin-Adair Co., New York. 1960. xii + 242pp. $6.00.

The purpose of this book is clearly spelled out in the publisher's preface: "To attempt to bridge the gap between a scientific monograph and a popular presentation of a suborder of birds, is to ask for trouble. Nevertheless, that is what has been tried here in the case of the American shorebirds." If the publisher expected trouble in this marriage of a "scientific" and "popular" approach, the author, editor, and illustrator have combined talents very nicely to protect the publisher from his dilemma. The readability, the ornithological accuracy, and the artistry of this book could each stand on its own merits.

The scope of the work describes in detail all 57 species of the suborder *Charadrii* which have been known to breed on the North American continent north of the Panama Canal. The discussion of each species includes all its races. This approach precludes the repetition so common in many detailed checklist accounts. A very brief description and distribution is given for South American shorebirds, followed by an enumeration of American shorebirds in Europe, European shorebirds in America, and Siberian shorebirds in America.

The editor introduces the shorebirds as a group in Chapter 1 with an interesting summary of their range, adaptability, habitat preferences, protective coloration, and classification. One of Mr. Clements' salient features in this section is a discussion of the need for positive thinking in the conservation of shorebirds. Whereas woodcock and common snipe can hold their own under the gun pressure allowed by current regulations, most other species could not because of their gregarious nature, habitat preferences, hazardous migrations, low reproductive potential, and habitat destruction. With reference to the last, the editor very aptly points out that "If and when we decide that we want the other creatures to continue sharing the earth with us, we will have to leave room for them."

The text is enhanced immeasurably with 95 black and white drawings by John Henry Dick. A bibliography of 71 references is conveniently arranged in one section following the text. Nomenclature follows the latest A.O.U. revision. Wherever a species is common to both Great Britain and North America and the popular name differs, the British counterpart is added in parentheses. In other cases where the popular American name has recently been changed by the A.O.U., the older name also appears in parentheses.

The editor candidly admits that *A Gathering of Shorebirds* is "neither the long-awaited monograph nor a handbook of the North American shorebirds." It is, however, a polished and delightful series of sketches that should be a welcome addition to the library of both professional ornithologists and amateur birdwatchers.—HENRY A. HANSEN, Bureau of Sport Fisheries and Wildlife, Juneau, Alaska.

Fundamentals of Forestry Economics. By William A. Duerr. McGraw-Hill Book Company, Inc., New York. 1960. xii + 579pp. $9.50.

As its title indicates, this book deals with the application of economic principles to forestry. But its potential applicability is much broader, for much of what is contained in it could, with appropriate modifications, serve as guiding principles for the management and utilization of other natural resources.

Duerr starts by indicating the nature and significance of the forest economy and the reasons why forestry should be singled out for separate economic analysis. He then proceeds to deal with forest economics in terms of its four logical divisions, namely, the production and supply of forest resources; the demand for timber and the products derived therefrom; the institutional factors such as taxes, tenure, credit, and market structures that are particularly significant in influencing the forests and forest industries; and, lastly, the operation and planning of the forest economy as a whole.

One cannot but be tremendously impressed by the thoroughness with which the author deals with all phases of his subject matter. Whether he is discussing such abstract concepts as production functions, iso-cost and revenue curves, or price elasticity of demand, or practical issues such as forest taxes, insurance, or land-use planning, his treatment is exhaustive and penetrating, and his conclusions well and carefully reasoned. In the analytical chapters—and many of them are—the emphasis is on the establishment of general principles. However, these principles are not left as abstract concepts, but are pointed toward practical applications. Concrete and specific illustrations of their usefulness in forestry operations are invariably given. Thus, the student can see that the abstract analytical tools which have been developed are not only useful but are indeed fundamental to an understanding of the basic relationships existing in the forest economy. Duerr combines, in an effective manner, his extensive firsthand knowledge of practical forestry with an intimate knowledge of economic theory. In so doing, he produces both an important and scholarly book. In the reviewer's

opinion, this book will remain for some time the unquestioned leader in its field and indeed may well become a classic.

As one would suspect, because of its strong emphasis on fundamentals and its substantial excursion into microeconomic theory, this book is sometimes difficult reading. The reader is rather quickly immersed in complicated and sophisticated concepts which he may at times find tough going unless he is familiar with some of the more elaborate tools of analysis used by the economist. Nevertheless, a careful reading of this book will prove to be a rewarding experience.

Duerr treats all of the many aspects of forestry economics in such a thorough and convincing manner that it is hard to single out separate topics for special praise. The reviewer was particularly impressed by his analysis of the optimum combination of the factors of production as applied to the individual firm. But several other subjects were also discussed with great clarity, insight, and completeness. In this connection, special mention should be made of his analysis of prices and price determination, the role of interest in the forest economy, and the significance and impact of taxes on forests and forest industries. The author's subtle humor adds a lively touch, and the occasional pertinent question posed in the text will provide the instructor with ample material for classroom discussion.

It is difficult to point to serious flaws in a book that was written with such obvious care. At times the discussion seems to have been made unnecessarily complicated for the student by the introduction of alternate methods of analysis. The author justifies this procedure by remarking (p. 64) that "One can do better work with a shovel if he learns to hold it left-handed as well as right-handed." But how many of us seek to be ambidextrous with a shovel to increase our efficiency with it?

The chief defects of this book stem from the failure of the author to treat, in a full and satisfactory manner, some important policy issues. On page 154, Duerr discusses extensive and intensive management and points out that "what is intensive is not necessarily good and what is extensive is not necessarily poor." This important point would seem to deserve more thorough treatment. A more serious omission is Duerr's failure to give the reader some guidance in arriving at a decision concerning an important issue raised on pages 31–33. The issue, the possibility of an impending timber shortage in the United States, has been argued in this country for decades. Two opposing schools of thought exist: One views with alarm the depletion in amount and quality of our timber resources. The other school believes that rapid advances in wood technology and utilization are materially expanding the wood supply. Which view is more nearly correct? What are the facts? This reviewer read hopefully through Duerr's book anticipating, in his concluding chapters, some further discussion of, and conceivably a reasoned opinion on, this important policy issue. Since Duerr is so obviously qualified to probe into this issue and to give such an opinion, his failure to do so is particularly regrettable. This seemed to be the only major deficiency of an otherwise excellent book.—JOHN A. GUTHRIE, Professor of Economics, Washington State University, Pullman, Washington.

The Meaning of Wilderness to Science. Edited by David Brower. Sierra Club, Berkeley, California. 1959. xi + 130pp. + 62 plates. $5.75.

Every other year since 1949 the Sierra Club has sponsored a Wilderness Conference. "The Meaning of Wilderness to Science" is a record of the sixth such meeting, held in 1959. Unlike most conference publications, what appears in this book is what was said, not what was written, by the guest participants. One happy result is that the reader can always see the pink slip of deep emotion peeking out from under the lab coats and academic gowns of the speakers. Talks by seven renowned scientists comprise the bulk of this volume, but included also are a foreword by David Brower, 62 pages of photographs of Alaska, discussions of papers, 8 resolutions proposed at the close of the conference, and an appended lecture-essay on natural beauty by G. M. Trevelyan (given originally in 1931).

"The Meaning of Wilderness to Science" is worth reading, but I was disappointed that the contents did not have more to do with the title. Perhaps that is the norm in scientific conferences loosely related by a single theme. Only two of the seven major papers "answer with firmer discipline the question of why wilderness has such great scientific importance," to use the words of F. Fraser Darling, a participant. Dr. Darling's contribution is one, the other is Luna B. Leopold's. The others treat a variety of subjects: Raymond Cowles discusses the impossibility of having wilderness at all in the rising clamor for space and materials; Ian McTaggart Cowan's talk centered around 33 photographic slides (undoubtedly beautiful, but not shown in the book) of southwestern Canada's wilderness and wild animals. Robert L. Rausch's paper on Alaska consists of three annotated checklists (on Alaskans and their livelihood, on the status of some wild animals, and on the state's National Parks, Monuments, Wildlife Refuges and Forests); Daniel Beard comments briefly on an array of ideas from the place of fire in wilderness to the value of things of unknown value; Stanley Cain challenges the National Park Service (and all of us) to begin a truly comprehensive program of basic research on wild lands and to put across this information to the public in a more exciting way. Even the 62 pages of photographs of scenery and animals in Alaska, though inspiring, relate only indirectly to the title of the book.

Both Leopold and Darling point out that wild areas are useful to natural science mainly as refer-

ence points, a fact which also seems to be the consensus of the whole conference. As a geologist with a good knowledge of biology, Luna Leopold was able to pry "the comfortable ecologist" from various long-held assumptions that prove to be based on inference rather than evidence. For example, do we really know that the rate of gullying in arid lands or the number of floods in wetter areas has increased because of our own activities? To prove it we need a datum plane, which we do not have and will not be able to get without studies of relatively undisturbed watersheds. The discussion after Leopold's paper showed that not a few ecologists were startled by the speaker's doubts that small reservoirs and lots of vegetation are panaceas for decreasing rates of ground water recharge. The speaker was not concerned with the pro's or con's of the problem, but only with the fact that there is a question and that there is a need for long-term wild land studies. Darling took an entirely different tack to show the same need. He demonstrates that wilderness is the most complex biological system of energy-conversion cycles, and that man's efforts usually cause a simplification of the system with a concomitant loss of efficiency and actual damage to the substrate. In grassland Africa, to use his example, 30 kinds of wild ungulates may use one undisturbed area. When men substitute three kinds of domestic ungulates, there is a decrease in protein production and a very great damage to the soil and plant cover. Any time that we want to see whether man's activities have increased the conversion rate of energy, or merely redirected it with losses, we need wilderness areas to serve as experimental controls.

All of the other authors, and many discussion participants, had things to say that are well worth thinking about. But to me, all other ideas were secondary to this: regardless of whether the numbers of people on earth increase to almost unimaginable heights, or stabilize at a level not much higher than exists today, the survival of natural areas depends on our ability to create a mental climate that makes wilderness possible. We must jar the apathy of our society, we must prove the value of wilderness in such a way that the general populace of our country demands wilderness or natural areas as part of the foundation of our standard of living, and as a treasured civil right.—ROBERT B. WEEDEN, Alaska Department of Fish and Game, College, Alaska.

The Recent Mammals of Arizona/Their Taxonomy and Distribution. By E. Lendell Cockrum. The University of Arizona Press, Tucson. 1961. viii + 276pp., 112 maps. $6.50.

This well-prepared book is strictly for the specialist and will be of little value to the layman or even to those wildlife biologists who have had no formal work in mammalogy. If one has sufficient background to interpret the technical jargon of the Key to Species or if one already knows the species in question, then the book will be a handy reference to that species' distribution in Arizona and to the literature pertaining to it. The book contains no descriptions of the various mammals considered, no photographs to aid in identification, and no natural history accounts. It deals strictly with taxonomy and distribution. To the technical mammalogist interested in the mammals of Arizona, the publication is a valuable reference.

In all, 290 different "kinds" (species and subspecies) of mammals are known to occur in Arizona, a fact which gives that state a mammalian fauna second (in the United States) only to California in terms of number of kinds. This is not too surprising when one considers the geographic position of Arizona and its varied climate, topography, soils, and vegetation.

The author anticipates the publication of a more comprehensive treatise on the mammals of Arizona at a later date, and he considers the current book as merely a "progress report" with three major aims: (1) to summarize distributional data for Arizona; (2) to point up problems needing solution; (3) to encourage further study of the mammals of the state. Thus, we may consider the present work as a basic segment of a more definitive future publication on the mammals of Arizona.

The book is well written and The University of Arizona Press has done a masterful job of printing and binding.—W. B. DAVIS, Department of Wildlife Management, Texas A. and M. College, College Station, Texas.

NOTICE TO CONTRIBUTORS OF ARTICLES TO THE JOURNAL OF WILDLIFE MANAGEMENT

The Wildlife Society is arranging to use the business management and redactory services of the American Institute of Biological Sciences. The Editor, JOURNAL OF WILDLIFE MANAGEMENT, will continue to receive manuscripts intended for THE JOURNAL. The present system of reviewing manuscripts will continue, but the Editor will forward manuscripts accepted for publication to the American Institute of Biological Sciences for handling during the stages leading to final printing. Contributors of articles accepted for publication should return galley proof, and address inquiries concerning it, to Redactory Services, THE JOURNAL OF WILDLIFE MANAGEMENT, 2000 P Street, NW, Washington 6, D. C.

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1940–41	Cahalane, V. H.	Needham, P. R.	Edminster, F. C.	Chase, W. W.	McAtee, W. L.
1941–42	Gerstell, Richard	Taylor, W. P.	Edminster, F. C.	Yeager, L. E.	McAtee, W. L.
1942–43	Needham, P. R.	Hendrickson, G. O.	Bennett, L. J.	Yeager, L. E.	Storer, T. I.
1943–44	Taylor, W. P.	Murie, O. J.	Bennett, L. J.	Wade, D. E.	Storer, T. I.
1944–45	Murie, O. J.	Yeager, L. E.	English, P. F.	Wade, D. E.	Storer, T. I.
1945–46	Yeager, L. E.	Swanson, G. A.	English, P. F.	Wade, D. E.	Storer, T. I.
1946–47	English, P. F.	Wade, D. E.	Bennett, L. J.	Dalke, P. D.	Storer, T. I.
1947–48	Bennett, L. J.	Storer, T. I.	Petrides, G. A.	Dalke, P. D.	Mills, H. B.
1948–49	Storer, T. I.	Cowan, I. McT.	Petrides, G. A.	Dalke, P. D.	Mills, H. B.
1949–50	Cottam, Clarence	Kalmbach, E. R.	Aldous, S. E.	Baker, M. S.	Mills, H. B.
1950–51	Cowan, I. McT.	Rasmussen, D. I.	Aldous, S. E.	Gresh, W. A.	Swanson, G. A.
1951–52	Chase, W. W.	Leedy, D. L.	Glazener, W. C.	Gresh, W. A.	Swanson, G. A.
1952–53	Leedy, D. L.	Dalke, P. D.	Glazener, W. C.	Cheatum, E. L.	Swanson, G. A.
			Executive Secretary		
1953–54	Clarke, C. H. D.	Glazener, W. C.	Petrides, G. A.; Leedy, D. L.		Hewitt, O. H.
1954–55	Swanson, G. A.	Evans, T. R.	Leedy, D. L.		Hewitt, O. H.
1955–56	Leonard, J. W.	Cheatum, E. L.	Leedy, D. L.		Hewitt, O. H.
1956–57	Allen, D. L.	Gottschalk, J. S.	Leedy, D. L.		Hewitt; Hickey
1957–58	Leopold, A. S.	Miller, R. B.	Leedy, D. L.; Linduska, J. P.		Hickey, J. J.
1958–59	Dambach, C. A.	Hewitt, O. H.	Linduska, J. P.		Hickey, J. J.
1959–60	Dambach, C. A.	Mosby, H. S.	Linduska, J. P.		Hickey; Kirkpatrick, C. M.
1960–61	Cheatum, E. L.	Berryman, J. H.	Linduska, J. P.; Fredine, C. G.		Kirkpatrick, C. M.
1961–62	Cheatum, E. L.	Berryman, J. H.	Fredine, C. G.		Kirkpatrick, C. M.

Editors of Wildlife Society News (and its predecessors): L. A. Luttringer, Jr. (1939–41), W. R. Van Dersal (1941–42), D. E. Wade (1942–43), R. E. Trippensee and V. H. Cahalane (1944–45), C. A. Dambach (1945–48), H. S. Mosby (1948–55), and T. R. Evans (1955–).

Editors of Wildlife Monographs: W. O. Nagel (1958), L. A. Krumholz (1958–).

Regional Representatives, Wildlife Society, 1937–61[1]

Year	Region I	Region II	Region III	Region IV	Region V	Region VI
1937	Allen, A. A.	Howard, W. J.	Graham, S. A.	Davison, V. E.	Taylor, W. P.	Sumner, E. L.
1938	King, R. T.	Howard, W. J.	Graham, S. A.	Roberts, P. H.	Taylor, W. P.	Sumner, E. L.
1939	Hosley, N. W.	Stoddard, H. L.	Swanson, G. A.	Murie, O. J.	Vorhies, C. T.	Sumner, E. L.
1940	Hosley, N. W.	Davison, V. E.	Ruhl, H. D.	Kalmbach, E. R.	Taylor, W. P.	Dixon, J. S.
1941	Bennett, L. J.	Gresh, W. A.	Ruhl, H. D.	Murie, O. J.	Borell, A. E.	Rasmussen, D. I.
1942	Pearce, John	Gresh, W. A.	Chase, W. W.	Murie, O. J.	Taylor, W. P.	Jewett, S. G.
1943	Pearce, John	Komarek, E. V.	Swanson, G. A.	Mills, H. B.	Goodrum, P. D.	Needham, P. R.
1944	Pearce, John	Komarek, E. V.	Chase, W. W.	Kalmbach, E. R.	Borell, A. E.	Needham, P. R.
1945	Pearce, John	Davison, V. E.	Chase, W. W.	Kalmbach, E. R.	Taylor, W. P.	Needham, P. R.
1946	Studholme, A. T.	Davison, V. E.	Allen, D. L.	Murie, O. J.	Lay, D. W.	Needham, P. R.
1947	Studholme, A. T.	Davison, V. E.	Chase, W. W.	Kalmbach, E. R.	Glazener, W. C.	Needham, P. R.
1948	Studholme, A. T.	Watson, C. W.	Gresh, W. A.	Kalmbach, E. R.	Taylor, W. P.	Moffett, I. W.
1949	Allen, D. L.	Watson, C. W.	Chase, W. W.	Kimball, J. W.	Davis, W. B.	Leopold, A. S.
1950	Allen, D. L.	Watson, C. W.	Evans, T. R.	Yeager, L. E.	Glazener, W. C.	Needham, P. R.
1951	Allen, D. L.	Foote, L. E.	Evans, T. R.	Yeager, L. E.	Davis, W. B.	Glading, Ben
1952	Allen, D. L.	Haugen, A. O.	Evans, T. R.	Mohler, L. L.	Davis, W. B.	Leopold, A. S.
1953	Latham, R. M.	Foote, L. E.	Evans, T. R.	Yeager, L. E.	Baumgartner, F. M.	Leopold, A. S.
1954	Latham, R. M.	Foote, L. E.	Douglass, D. W.	Yeager, L. E.	Baumgartner, F. M.	Lauckhart, J. B.
1955	Latham, R. M.	Foote, L. E.	Douglass, D. W.	Yeager, L. E.	Swank, W. G.	Leopold, A. S.
1956	Latham, R. M.	Chamberlain, E. B.	Crawford, B. T.	Yeager, L. E.	Baumgartner, F. M.	Leopold, A. S.
1957	Latham, R. M.	Chamberlain, E. B.	Crawford, B. T.	Yeager, L. E.	Baumgartner, F. M.	Yocom, C. F.
1958	Latham, R. M.	Chamberlain, E. B.	Crawford, B. T.	Yeager, L. E.	Walker, E. A.	Dasmann, R. F.
1959	Latham, R. M.	Strode, D. H., Glasgow, L. L.	Berryman, J. H.	Yeager, L. E.	Swank, W. G.	Dasmann, R. F.
1960	Latham, R. M. DeGarmo, W. R.	Glasgow, L. L.	Crawford, B. T.	Yeager, L. E.	Swank, W. G.	Leach, H. R.
1961	Coulter, M. W.	Glasgow, L. L.	Crawford, B. T.	Yeager, L. E.	Swank, W. G.	Low, J. B.

Region VII (Authorized in 1946)

1946–47	Cowan, I. McT.	1955–56	Cowan, I. McT.	1961–62	Fowle, C. D.
1948–49	Clarke, C. H. D.	1957	Edwards, R. Y.		
1950	Harkness, W. J. K.	1958–59	Munro, D. A.		
1951–54	Fowle, C. D.	1960–61	Munro, D. A.		

[1] The year shown is the start of each fiscal year; usually this is about mid-March.